

**NL/GOULD SUPERFUND SITE
PORTLAND, OREGON**

**WACKER SILTRONIC CORPORATION
GOULD BATTERY SITE REPORT**

TO: Distribution
FROM: Greg Carr
SUBJECT: Gould Battery Site Report
DATE: January 29, 1988

Distribution:

Jim Ellis
Don Crane
Murray Tilson

EXECUTIVE SUMMARY

This report presents the results of the remedial investigation for Gould Inc. and NL Industries, Inc. as required by Administrative Order on Consent (Consent Order) EPA Docket No. 1085-05-08106, dated August 29, 1985. The study covers property currently owned by Gould (previously owned by NL Industries) and adjacent properties owned by other property owners. The purpose of the remedial investigation was to:

- ° Characterize the extent of contamination at the site, a former secondary lead smelter;
- ° Assess the existing and potential threats to human health and environment; and
- ° Identify potentially applicable remedial technologies.

The remedial investigation included:

- ° Collection of historical data available for the site;
- ° A literature review of urban lead contamination (reported elsewhere);
- ° A characterization of the existing study area with regard to potential contamination of surface and subsurface soils, lake and river sediments, and surface water and ground water;
- ° Assessment of lead contamination in waste stockpiles;
- ° Assessment of airborne lead contamination resulting from site activities;
- ° Assessment of potential pathways for contaminant migration from the site; and
- ° Preliminary evaluation of potential remedial actions.

Site Features Investigation Results

The smelter was originally constructed in 1948 upon a site constructed with fill materials placed in an oxbow lake, Doane Lake, formed by the nearby Willamette River. The plant operated several different processes including lead-acid storage battery breaking and grid metal separation, lead smelting and refining, lead oxide manufacturing, zinc alloying, and electrical cable stripping. The plant operated from 1949 through 1972, at which time the smelter was shut down. Battery-breaking operations and lead oxide manufacturing continued at the plant until 1981. Waste materials from the operations were generally deposited on the plant or adjacent properties. In 1983, a company called Alchem Western was unsuccessful in its attempt to operate equipment to separate plastic from hard rubber casings in the mixture remaining on the Gould property.

The site is located in an industrial area with low population density and few residences in the general vicinity. The site is relatively flat, with very little vegetation or wildlife. Two remnants of Doane Lake were included in the study area. No rare, threatened, or endangered species are known to inhabit the area, although the nearby Willamette and Columbia Rivers provide habitat for substantial waterfowl and fish species. A City of Portland park (Forest Park) is located southwest of the study area. The climate of the area is heavily influenced by Pacific Ocean air masses which bring abundant rainfall. Other features affecting the local climate of the site include the coastal mountain range, the Cascade Mountains, and the Columbia River Gorge which allows continental air masses to move into the area occasionally. Airborne baghouse emissions exceeding federal and state air quality standards have been observed during plant operations in previous years.

Surface Debris Investigation Results

Investigations of smelter wastes used as fill material in the study area identified two types of materials: shredded battery casings and a slag-like material referred to as matte. Casing materials consist of

polyester plastic, hard rubber (ebonite), lead oxide residues, small amounts of lead and non-lead metal, and other scrap materials such as iron, rock and wood. Composition of the shredded casings varies widely, with total lead concentrations (metallic lead and lead oxide) from 3.1 to 14.5 percent. The casing samples tested failed the Resource Conservation and Recovery Act (RCRA) EP Toxicity leachate analysis for lead.

The matte consists primarily of rock-like chunks composed of metallic sulfides, principally iron, and contains 6 to 11 percent lead. This material is the principal waste resulting from the smelting and refining operations, and it is estimated that about 12,000 tons were produced over the years of smelter operation. Matte also fails the RCRA EP Toxicity leachate analysis for lead.

During the years in which the smelter operated (1949 to 1973), about 2,600 tons per year of shredded battery casings were reportedly used as off-site fill material in West Doane Lake, on property belonging to Rhone-Poulenc Inc. (west of the Gould property). As the casings were placed, earthen fill was placed over the top of the casing material to create a level site. Matte was used as fill in the portion of Doane Lake on the northeastern boundary of the Gould property (referred to in the remedial investigation report as the "East" Doane Lake remnant). After shutdown of the smelter in 1973, shredded battery casings were placed on site over the matte and into the East Doane Lake remnant. The reported amount of shredded casings used as fill on the Rhone-Poulenc and Gould properties is estimated from production figures to be approximately 75,000 tons.

A discrepancy between the estimated volume of pre-1973 battery casings reportedly disposed off site on Rhone-Poulenc property and the estimated volume of casings actually found on Rhone-Poulenc property, indicates that approximately 40,000 cubic yards of pre-1973 casing material was unaccounted for. Estimates of the volume of casings used as fill on the Gould property indicate a surplus of approximately 56,000 cubic yards. Aerial photographs indicate that some or all of the 40,000 cubic yards of unaccounted pre-1973 casings have been used as fill on site, contrary to reported disposal practices.

Waste sulfuric acid solutions from the battery breaking operations were discharged into the east Doane Lake remnant for most of the years the plant was in operation. Volumes of waste acid that were being discharged into Doane Lake during this period are estimated at 274,000 gallons per year. In 1976, treatment of this acid commenced with the treated waste being discharged into the City of Portland sewer system.

Other waste material identified in the study area included: 1) an alkaline hydrated lime waste from the manufacture of acetylene discharged into the east Doane Lake remnant; 2) shredded automobile body interiors placed on the property owned by Schnitzer Investments, to the east of the Gould property; and 3) demolition debris placed on the property owned by Rhone-Poulenc, west of the Gould property. The composition and quantity of these materials were not assessed during the Remedial Investigation.

Hydrogeology Investigation Results

The site is underlain by a variety of volcanic and sedimentary rocks, including the Scappoose and Columbia River Basalt deposits. Holocene age alluvial sands, silts and clays deposited by flooding of the Willamette River underlie the study area to depths of 38 to about 93 feet below the floodplain. A prehistoric channel of the Willamette River cut off by later alluvial deposits formed Doane Lake, which was present over most of the study area at the time of industrial development. Imported fill material placed into Doane Lake created the site for smelter construction.

The geology of the site affects the amount, movement and quality of ground water in the study area. Basalt flows with rubble tops contain most of the ground water and underlie the study area. These flows, numbering 12 to 14, dip to the northeast from the Portland Hills anticline under Forest Park into the Portland Basin containing the Willamette River.

The alluvium (below the fill layer) on site consists of a complex mixture of river channel sands, silts and clays. Chemical analyses of

the alluvium for metals indicate that the range of concentrations found are for the most part within the range of background concentrations that have been reported for the area. Lead levels observed varied from 23 to 110 parts per million (ppm). The highest lead levels observed in the alluvium were near the contact point with the fill later added to Doane Lake.

A range of fill materials was placed into Doane Lake including metal slag, scrap metal, demolition debris, hydraulic dredge spoils, rock quarry spoils, shredded automobile interiors, and acetylene sludge as well as battery casings and matte. The fill is generally much more permeable than the alluvium. Metal contamination in the fill ranges locally up to several parts per million of chromium, cadmium, zinc, and arsenic. The pattern of contamination appears directly related to the known site history and types of fills placed within Doane Lake. No obvious pattern of contaminant migration is occurring within the fill materials. Lead concentrations of up to 10 percent lead have been observed within the area where battery casing fill has been placed.

Sediment samples taken within the east and west Doane Lake remnants showed the highest concentrations of lead. East Doane Lake remnant sediments had lead values ranging from 160 to 12,000 ppm. West Doane Lake remnant sediments were observed to have between 870 to 1,500 ppm. The Willamette River sediments taken upstream and downstream of the discharge area from the Gould property had observed lead concentrations of 26 to 56 ppm, equivalent to background levels reported for the Willamette River.

Precipitation runoff from the Gould property and from surrounding properties is the only other source of surface water on site. The east Doane Lake remnant discharges at high water levels into a storm sewer that subsequently enters the Willamette River. There is no surface discharge from the west Doane Lake remnant. Water is lost through percolation and evaporation. Tidal influences in the Willamette River were observed to fluctuate as much as 4 feet in a 24-hour period. Part of the Gould property is located within the 100-year floodplain.

Four water-bearing units were identified beneath the site. These units are the fill, the upper alluvial, the lower alluvial and the basalt. The units are hydraulically connected, but the properties vary widely with material type and permeability. Recharge occurs through precipitation, infiltration from the Doane Lake remnants, and lateral inflow. Horizontal hydraulic gradients varied from about 3 feet in 400 feet to 4 feet in 1,500 feet. The direction of ground-water flow is northward toward the Willamette River.

Dissolved lead concentrations up to approximately 0.21 ppm were found in ground water in the monitoring wells within the casing disposal areas. Elevated sulfate and lead concentrations were found in wells downgradient of the battery casing disposal area. The partitioning illustrated by total lead, total recoverable lead and dissolved lead indicate that dissolved lead concentrations in ground water are relatively low downgradient. The potential for lead migration exists only if pH were to decrease.

Surface soil concentrations of lead were high in only those areas sampled around the old plant site on the Gould property and on the Rhone-Poulenc property above the battery casings disposal area.

Air Investigation Results

Results of airborne lead sampling over the course of remedial investigations (April 1986 through January 1987) demonstrated that airborne lead concentrations at the Gould property boundaries are currently well below both federal and state air quality standards for lead. On several occasions significantly higher concentrations of airborne lead were observed for single days at one monitor. Observations by Dames & Moore personnel on site during those days attributed the higher readings to cleanup operations by a purchaser of the Alchem Western casing separation equipment. The investigation concluded that, with no disturbance of the material on site, airborne lead levels present no imminent public health hazard. However, remedial action will need to take into account that significant airborne lead levels may occur as contaminated materials are disturbed.

Biota Investigation Results

No data were located for contaminant uptake by plants on the site. However, the area is largely devoid of vegetation. Onsite occurrence of animals is low due to limited habitat. No data were located for contaminant concentrations in onsite fauna. Limited data on metal concentrations in Willamette River fish and invertebrates were available. Concentrations of lead ranged from 0.68 ppm in crayfish tissue to 0.24 ppm in fish tissue (peamouth). Three other fish species analyzed for tissue lead concentrations were all below the detection limit (0.1 ppm).

Bench Scale Studies

A bench scale study of limited scope was performed during the Remedial Investigation. Three types of coatings for battery casings were tested using the RCRA EP Toxicity Method for determining the effectiveness of each coating's ability to reduce leachable lead. The coating formulations were not effective in reducing the leachable lead levels below acceptable levels.

Batch adsorption tests were run to assess the ability of soils in the study area to retard the transport of lead in ground water. Results suggest that the lead adsorptive capacity of the study area soils and sediments is quite high, and thus the soils are effective at inhibiting lead migration.

Leach potential tests were performed to evaluate the potential for lead to leach from battery casings, matte and contaminated soils and sediment under varying ground-water acidity/alkalinity (pH) conditions using actual ground water from the site. Results confirm the amphoteric nature of lead; its solubility increases as acidity or alkalinity changes from a pH of 8 to 9.

Public Health and Environmental Concerns

Potential human receptors in the study area are primarily workers at surrounding places of employment and those living in the few residences near Forest Park. Except for a part-time caretaker who oversees site activities, the Gould site itself is vacant and has limited access. Potential pathways for human exposure are primarily inhalation of contaminant-laden airborne dust and soil ingestion. Except during periods of heavy site activity, airborne lead levels as noted above are below air quality standards and no known drinking water wells are located on or downgradient from the site.

Potential pathways of contaminant exposure to flora and fauna are primarily through uptake of contaminated water or ingestion of contaminated plant material or pond sediments. Bioaccumulation of heavy metals is possible through the food chain. Transfer to humans is possible through game birds known to be present in the area. In the Doane Lake remnants, there are no aquatic species present that might be consumed by humans.

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
EXECUTIVE SUMMARY.....	i
TABLE OF CONTENTS.....	ix
LIST OF TABLES.....	xv
LIST OF FIGURES.....	xvi
1.0 INTRODUCTION.....	1-1
1.1 INVESTIGATION SUMMARY.....	1-1
1.1.1 Purpose and Scope of Remedial Investigation.....	1-1
1.1.2 Overview of Remedial Investigation.....	1-1
1.2 OVERVIEW OF REPORT.....	1-2
1.3 SITE BACKGROUND INFORMATION.....	1-4
1.3.1 Site Location and Configuration.....	1-4
1.3.2 Site History.....	1-7
1.3.3 Site Topography and Physiography.....	1-8
1.3.4 Other Information.....	1-15
1.4 NATURE AND EXTENT OF THE PROBLEM.....	1-18
1.4.1 Characteristics and Extent of Wastes.....	1-18
1.4.2 Special Waste Considerations.....	1-20
1.4.3 Present Conditions of Materials and Structures.....	1-20
1.4.4 Planned Changes in Site.....	1-20
1.4.5 Potential Pathways and Impacts of Contaminants from Site.....	1-20
1.4.6 Previous Actions to Mitigate Problem.....	1-21
2.0 SITE FEATURES INVESTIGATION.....	2-1
2.1 DEMOGRAPHY.....	2-1
2.1.1 Population.....	2-1
2.1.2 Employment.....	2-2
2.1.3 Housing.....	2-2
2.2 LAND USE.....	2-2
2.2.1 Existing Land Use.....	2-2
2.2.2 Planned Land Use.....	2-4
2.2.3 Land Use Plans and Controls.....	2-4
2.3 NATURAL RESOURCES.....	2-4
2.3.1 Vegetation.....	2-4
2.3.2 Wildlife.....	2-6
2.3.3 Aquatic Resources.....	2-7
2.3.4 Rare, Threatened, or Endangered Species.....	2-7
2.3.5 Sensitive Species or Habitats.....	2-7
2.3.6 Parks and Recreation Areas.....	2-8
2.3.7 Natural Resource Development.....	2-9

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
2.4 CLIMATOLOGY.....	2-9
2.4.1 Regional Weather Patterns.....	2-9
2.4.2 Local Climate.....	2-10
2.4.2.1 Wind.....	2-10
2.4.2.2 Temperature.....	2-11
2.4.2.3 Precipitation.....	2-13
2.4.2.4 Evapotranspiration.....	2-13
3.0 HAZARDOUS SUBSTANCES INVESTIGATION.....	3-1
3.1 INTRODUCTION.....	3-1
3.2 WASTE TYPES.....	3-1
3.2.1 Site Process Waste Sources.....	3-2
3.2.1.1 Smelter Operations.....	3-2
3.2.1.2 Other Site Operations.....	3-4
3.2.2 Other Potential Waste Sources.....	3-4
3.2.2.1 Adjacent Industries.....	3-4
3.2.2.2 Landfilling Operations.....	3-4
3.2.2.3 Secondary Sources.....	3-7
3.2.3 Disposal Locations.....	3-8
3.2.3.1 Historic Disposal Locations.....	3-8
3.2.3.2 Results of Remedial Investigation.....	3-8
3.2.4 Waste Quantities, Components and Composition.....	3-12
3.2.4.1 Waste Quantities and Components.....	3-13
3.2.4.2 Waste Composition.....	3-20
3.2.5 Waste Containment.....	3-25
3.2.5.1 Geochemical.....	3-25
3.2.5.2 Stratigraphic.....	3-25
3.2.5.3 Hydraulic.....	3-25
3.2.5.4 Anthropogenic.....	3-26
3.3 WASTE COMPONENT CHARACTERISTICS AND BEHAVIOR.....	3-26
3.3.1 Toxicity, Bioaccumulation and Metabolism.....	3-26
3.3.2 Environmental Transformation.....	3-26
3.3.3 Transport Behavior.....	3-27
3.3.3.1 Air.....	3-27
3.3.3.2 Soil.....	3-27
3.3.3.3 Water.....	3-28

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
4.0 HYDROGEOLOGY AND HYDROGEOLOGY INVESTIGATIONS	4-1
4.1 SCOPE OF INVESTIGATIONS.....	4-1
4.2 GEOLOGY	4-2
4.2.1 Regional Geology.....	4-2
4.2.2 Site Geology.....	4-4
4.2.2.1 Fill	4-4
4.2.2.2 Holocene Alluvium	4-5
4.2.2.3 Columbia River Basalt.....	4-8
4.2.2.4 Doane Lake and Willamette River Sediments..	4-8
4.3 HYDROLOGY	4-18
4.3.1 Precipitation	4-18
4.3.2 Surface Drainage Patterns	4-18
4.3.3 Doane Lake Remnants	4-19
4.3.4 Willamette River	4-19
4.4 HYDROGEOLOGY	4-22
4.4.1 Regional Hydrogeology	4-22
4.4.2 Site Hydrogeology	4-23
4.4.2.1 Overview	4-23
4.4.2.2 Fill Water-Bearing Unit	4-25
4.4.2.3 Alluvial Water-Bearing Units.....	4-26
4.4.2.4 Basalt Water-Bearing Unit	4-27
4.4.3 Hydrogeologic Parameters	4-28
4.4.3.1 Water Level Fluctuations	4-28
4.4.3.2 Hydraulic Gradients	4-31
4.4.3.3 Hydraulic Conductivity	4-33
4.4.3.4 Transmissivities	4-35
4.4.3.5 Ground-Water Flow Velocity	4-36
4.4.3.6 Annual Water Budget Analyses for the Fill Alluvial Aquifers	4-37
4.5 CONTAMINANT MIGRATION	4-63
4.5.1 Contaminants	4-63
4.5.2 Soil Contaminant Delineation	4-63
4.5.2.1 Fill	4-63
4.5.2.2 Doane Lake and Willamette River Sediments..	4-68
4.5.2.3 Alluvium	4-69
4.5.2.4 Columbia River Basalt	4-71

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
4.5.3 Ground-Water Contaminant Delineation	4-72
4.5.3.1 Lead in Ground Water	4-79
4.5.3.2 Fill Water-Bearing Unit	4-81
4.5.3.3 Upper Alluvial Water-Bearing Unit	4-82
4.5.3.4 Lower Alluvial Water-Bearing Unit	4-84
4.5.3.5 Basalt Water-Bearing Unit	4-85
4.5.3.6 Summary	4-85
4.5.4 Surface Water Contaminant Delineation	4-86
4.5.4.1 Willamette River	4-86
4.5.4.2 East and West Doane Lake Remnants	4-88
4.5.5 Contaminant Transport	4-90
4.5.5.1 Contaminant Sources	4-90
4.5.5.2 Lead Solubility On Site	4-91
4.5.5.3 Particulate Transport	4-92
4.5.5.4 Retardation	4-93
4.5.5.5 Contaminant Transport Velocity	4-94
4.5.5.6 Prediction of Lead Migration.....	4-95
5.0 AIR INVESTIGATION.....	5-1
5.1 INTRODUCTION AND BACKGROUND.....	5-1
5.2 SAMPLING PROGRAM.....	5-3
5.3 INVESTIGATION RESULTS.....	5-6
5.3.1 Concentrations of Airborne Lead.....	5-6
5.3.2 Meteorology.....	5-12
5.3.3 Quality Control Summary.....	5-21
5.4 POTENTIAL RISKS.....	5-22
5.4.1 Sources of Airborne Lead On Site.....	5-22
5.4.1.1 Battery Casing Piles.....	5-22
5.4.1.2 Matte Disposal Area.....	5-23
5.4.1.3 Contaminated Soils.....	5-23
5.5 POTENTIAL ATMOSPHERIC CONTAMINANT MIGRATION.....	5-23
6.0 BIOTA INVESTIGATION.....	6-1
6.1 FLORA.....	6-1
6.1.1 Site and Local Distribution.....	6-1
6.1.2 Contaminant Concentrations.....	6-1

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
6.2 FAUNA.....	6-1
6.2.1 Site and Local Distribution.....	6-1
6.2.2 Contaminant Concentration.....	6-2
7.0 BENCH SCALE STUDIES.....	7-1
7.1 INTRODUCTION.....	7-1
7.2 BATTERY CASING COATING TEST.....	7-1
7.2.1 Purpose.....	7-1
7.2.2 Procedure.....	7-1
7.2.3 Results.....	7-3
7.2.4 Conclusions.....	7-3
7.3 BATCH ADSORPTION TEST.....	7-4
7.3.1 Purpose and Scope.....	7-4
7.3.2 Procedure.....	7-6
7.3.3 Results.....	7-7
7.3.4 Conclusions.....	7-13
7.4 LEACH POTENTIAL TEST.....	7-13
7.4.1 Purpose and Scope.....	7-13
7.4.2 Procedure.....	7-14
7.4.3 Results.....	7-15
7.4.4 Conclusions.....	7-18
8.0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS.....	8-1
8.1 POTENTIAL RECEPTORS.....	8-1
8.1.1 Humans.....	8-1
8.1.1.1 Demographics Near Site.....	8-1
8.1.1.2 Pathways of Contamination.....	8-1
8.1.2 Flora and Fauna.....	8-2
8.1.2.1 Endangered Species.....	8-2
8.1.2.2 Pathways of Contamination.....	8-2
8.1.2.3 Bioaccumulation of Contaminants.....	8-3
8.1.2.4 Transfer to Humans.....	8-3

TABLE OF CONTENTS (Concluded)

<u>Section</u>	<u>Page</u>
8.2 PUBLIC HEALTH.....	8-3
8.2.1 Human Health Effects of Site Contaminants.....	8-3
8.2.1.1 General.....	8-3
8.2.1.2 Arsenic.....	8-4
8.2.1.3 Cadmium.....	8-5
8.2.1.4 Chromium.....	8-5
8.2.1.5 Lead.....	8-6
8.2.1.6 Zinc.....	8-7
8.2.2 Exposure to Contaminated Areas.....	8-7
8.2.2.1 Review of Pathways of Contamination.....	8-7
8.2.2.2 Physiological Incorporation of the Contaminant.....	8-7
8.2.2.3 Applicability to Gould Site.....	8-8
8.3 ENVIRONMENTAL IMPACTS.....	8-9
8.3.1 Onsite Environmental Impacts.....	8-9
8.3.2 Off-site Environmental Impacts.....	8-10
9.0 REFERENCES.....	9-1
10.0 GLOSSARY.....	10-1

APPENDICES

Appendix A - Sampling and Analytical Procedures
Appendix B - Quality Assurance/Quality Control Program
Appendix C - Analytical Data
Appendix D - Hydrogeologic Investigation Data
Appendix D1 - Boring Logs and Well Completion Diagrams
Appendix D2 - Geophysical Logs
Appendix D3 - Water Level Data
Appendix D3.1 - Precipitation and River Stage Data
Appendix D3.2 - Monitoring Well Data
Appendix D3.3 - Monitoring Well Hydrographs
Appendix D3.4 - Continuous Stevens Recorder Data
Appendix D3.5 - Barometric Pressure Charts
Appendix D4 - Test Pit Logs
Appendix D5 - Physical Property Test Results

LIST OF TABLES

<u>Table</u>		<u>Page</u>
1.3-1	Chronological History of Gould Site Operations	1-9
2.2-1	Summary of Applicable Zoning Code Designations	2-5
2.2-2	City of Portland Zoning Code Designation Changes	2-6
2.3-1	Fish Species Identified from the Willamette River in the Vicinity of the Gould Site	2-8
2.4-1	Average Total Evaporation in Western Washington	2-14
3.2-1	Lead-Acid Battery Recycling and Secondary Lead Smelting Waste Products, Gould Facility 1949 to 1973	3-14
3.2-1a	Battery Casings and Matte Quantities and Locations	3-16
3.2-2	Battery Casing Sample Composition by Weight	3-21
3.2-3	Prepared Battery Casing Sample Analysis Results	3-22
3.2-4	Composition of Battery Casing Samples Collected on Gould Property	3-23
3.2-5	Matte Analysis Results	3-24
4.2-1	Physical Properties of Fill and Surface Soils	4-6
4.2-2	Physical Properties of Alluvium	4-7
4.4-1	Water Level Correlations	4-29
4.4-2	Gould Well Permeability Data: Monitoring Wells	4-34
4.5-1	Summary of Chemical Analyses, Subsurface Samples of Fill	4-65
4.5-2	Summary of Chemical Analyses, Surface Soils and Background	4-66
4.5-3	Summary of Chemical Analyses, Subsurface Samples of Alluvium	4-70
4.5-4	Elemental Concentrations in Basalt	4-72
4.5-5	Gould: Ground Water Round 1, Round 2, and Round 3 Analysis Results	4-73
4.5-6	Statistical Evaluation of Ground Water Chemistry Results, Rounds 1, 2, and 3	4-75
4.5-7	Correlation Between pH Dissolved Constituents	4-78
4.5-8	Federal Standards for Metals	4-82
4.5-9	Gould: Surface Water Round 1, Round 2, and Round 3 Analysis Results	4-89
5.1-1	Summary of Airborne Lead Concentrations Monitored by DEQ	5-2
5.1-2	Summary of Airborne Lead Concentrations Monitored by Dames & Moore and EPA Region X	5-3
5.3-1	Airborne Lead Concentrations, Daily Averages	5-7
5.3-2	Airborne Lead Concentrations, Monthly and Quarterly Averages	5-11
5.3-3	Wind Frequency Distribution, Rhone-Poulenc Site Aug. 11, 1986 to Nov. 30, 1986	5-13
5.3-4	Wind Frequency Distribution, Standard Oil Site Aug. 6, 1979 to Nov. 30, 1979	5-15
5.3-5	Wind Frequency Distribution, Standard Oil Site Aug. 1, 1977 to Nov. 30, 1977	5-16
5.3-6	Wind Frequency Distribution, Standard Oil Site Feb. 5, 1977 to Aug. 29, 1980	5-17
7.2-1	Battery Casing Coating Test Results	7-3
7.3-1	Batch Adsorption Test Results	7-8
7.3-2	Calculation Summary Table	7-11
7.4-1	Leach Potential Test Results	7-16

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1.3-1	General Vicinity Map	1-5
1.3-2	Study Area Location Map	1-6
1.3-3	Topographic Map of Site	1-14
1.3-4	1979 Site Condition	1-16
2.1-1	Existing Land Use and Zoning Code Designations	2-3
2.4-1	Wind Frequency Distribution	2-12
3.2-1	Process Flow Diagram	3-3
3.2-2	History of Fill On Site	3-6
3.2-3	Approximate Waste Disposal Locations and Battery Casing Test Pit & Sampling Locations	3-9
3.2-4	Matte Test Pit Locations	3-11
3.2-5	Surface Soil and Sediment Secondary Source Locations	3-18
4.2-1	Regional Geology	4-10
4.2-2	1880 Topography	4-11
Plate 4A	Geologic Cross-Sections A-A', B-B', C-C'	4-12
Plate 4B	Geologic Cross-Sections D-D', E-E', F-F'	4-13
Plate 4C	Geologic Cross-Sections G-G', H-H', I-I'	4-14
4.2-3	Cross-Section Location Map	4-15
4.2-4	Fill Thickness Map	4-16
4.2-5	Top of Basalt	4-17
4.3-1	Surface Drainage Boundaries	4-21
4.4-1	Conceptual Hydrogeologic Cross-Section J-J' October 23, 1986	4-43
4.4-2	Conceptual Hydrogeologic Cross-Section J-J' February 3, 1987	4-44
4.4-3	Piezometric Heads Flow Lines Cross-Section J-J' October 23, 1986	4-45
4.4-4	Piezometric Heads Flow Lines Cross-Section J-J' February 3, 1987	4-46
4.4-5	Conceptual Hydrogeologic Cross-Section E-E' October 23, 1986	4-47
4.4-6	Conceptual Hydrogeologic Cross-Section E-E' February 3, 1987	4-48
4.4-7	Piezometric Heads Flow Lines Cross-Section E-E' October 23, 1986	4-49
4.4-8	Piezometric Heads Flow Lines Cross-Section E-E' February 3, 1987	4-50
4.4-9	Ground-Water Elevation Contours, Fill Water-Bearing Unit, October 23, 1986	4-51
4.4-10	Ground-Water Elevation Contours, Fill Water-Bearing Unit, February 3, 1987	4-52
4.4-11	Ground-Water Elevation Contours, Middle and Upper Part Alluvial Water-Bearing Unit, October 23, 1986	4-53
4.4-12	Ground-Water Elevation Contours, Middle and Upper Part Alluvial Water-Bearing Unit, February 3, 1987	4-54
4.4-13	Ground-Water Elevation Contours, Lower Part Alluvial Water-Bearing Unit, October 23, 1986	4-55
4.4-14	Ground-Water Elevation Contours, Lower Part Alluvial Water-Bearing Unit, February 3, 1987	4-56

LIST OF FIGURES (Continued)

<u>Figure</u>		<u>Page</u>
4.4-15	Well, Lake and Willamette River Water Levels and Precipitation	4-57
4.4-16	Difference in Ground-Water Elevations Fill Water-Bearing Unit October 23, 1986 to February 3, 1987	4-58
4.4-17	Difference in Ground-Water Elevations, Upper Part of Alluvial Aquifer, October 23, 1986 to February 3, 1987	4-59
4.4-18	Difference in Ground-Water Elevations, Lower Part of Alluvial Aquifer, October 23, 1986 to February 3, 1987	4-60
4.4-19	Vertical Gradients Fill to Lower Alluvial Water-Bearing Unit, January 13, 1987	4-61
4.4-20	Conceptual Model of Water Budget Analysis	4-62
4.5-1	Well, Boring and Test Pit Locations	4-98
4.5-2	Surface Soil Sample Locations	4-99
4.5-3	pH in Surface Soils	4-100
4.5-4	Lead in Surface Soils	4-101
4.5-5	Arsenic in Surface Soils	4-102
4.5-6	Cadmium in Surface Soils	4-103
4.5-7	Chromium in Surface Soils	4-104
4.5-8	Zinc in Surface Soils	4-105
4.5-9	Iron in Surface Soils	4-106
4.5-10	Sulfate in Surface Soils	4-107
4.5-11	Lead Concentration Versus Distance from Doane Lake Remnants	4-108
4.5-12	Sediment Sample Location Map	4-109
4.5-13	Background Sample Locations	4-110
4.5-14	Total Recoverable Lead, Fill Aquifer	4-111
4.5-15	Total Recoverable Lead, Upper Alluvial Aquifer	4-112
4.5-16	Total Recoverable Lead, Lower Alluvial Aquifer	4-113
4.5-17	Sulfate and Dissolved Lead Plumes, Fill Aquifer	4-114
4.5-18	Sulfate and Dissolved Lead Plumes, Upper Alluvial Aquifer	4-115
4.5-19	Sulfate and Dissolved Lead Plumes, Lower Alluvial Aquifer	4-116
4.5-20	Surface Water Monitoring Locations	4-117
4.5-21	Theoretical Maximum Level Solubility Related to pH (Adapted from Osteryoung)	4-118
4.5-22	Observed Lead Solubility Related to pH	4-119
5.2-1	Air Quality and Meteorology Sampling Locations	5-5
5.3-1	Wind Frequency Distribution, Rhone-Poulenc Site, August 11, 1986 to November 30, 1986	5-14
5.3-2	Wind Frequency Distribution, Standard Oil Site, August 6, 1979 to November 30, 1979	5-18
5.3-3	Wind Frequency Distribution, Standard Oil Site, August 1, 1977 to November 30, 1977	5-19
5.3-4	Wind Frequency Distribution, Standard Oil Site, February 5, 1977 to August 29, 1980	5-20

1.0 INTRODUCTION

This report presents the results of remedial investigations for Gould Inc. and NL Industries, Inc. as required by Administrative Order on Consent (Consent Order), EPA Docket No. 1085-05-08-106, dated August 29, 1985. The investigation proceeded under Section 106(a) of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 [42 U.S.C. 9606(a)].

The study area consists of approximately 60 acres located in Multnomah County, Oregon, including 9.2 acres currently owned by Gould, Inc. and formerly owned by NL Industries, Inc. The 9.2-acre Gould property is located at 5909 N.W. 61st Avenue, Portland, Oregon.

1.1 INVESTIGATION SUMMARY

1.1.1 Purpose and Scope of Remedial Investigation

As mandated by the above-referenced order, the purpose of the remedial investigation was to:

- ° Characterize the extent of possible contamination at the site,
- ° Assess existing and potential threats to human health and the environment, and
- ° Identify potentially applicable remedial technologies for further study.

The scope of the investigation included an evaluation of the history of the Gould site and adjacent areas, evaluations of soil, water, and air contamination and contaminant pathways, and an assessment of potential human and environmental impacts.

1.1.2 Overview of Remedial Investigation

The remedial investigation included:

- ° Collection and evaluation of data readily available in various governmental and industrial files in order to provide a historical summary of study area activities.

- ° A review of scientific literature on urban lead contamination problems in order to provide information regarding the potential hazards of secondary lead smelter contamination, the significance of lead contamination on human health and the environment, and to provide a range of lead concentrations that have been monitored at similar urban sites.
- ° Characterization of existing study area features, as well as surface and subsurface conditions, with regard to potential sources of hazardous substance emissions, discharges, and contaminations.
- ° Assessment of concentration and extent of lead contamination in surface and subsurface soils in the plant and adjacent study area by sampling and testing waste stockpiles, surface water, bottom sediment, surface soils, subsurface soil borings, and ground water.
- ° Assessment of location, extent, and movement of potentially contaminated ground water by installation of 17 new monitoring wells, quarterly sampling of 34 wells, weekly monitoring of ground-water levels in 38 wells, and continuous water-level monitoring in two wells.
- ° Assessment of potential surface-water migration pathways and potential off-property environmental impacts.
- ° Assessment of the extent of airborne lead contamination resulting from site activities.
- ° Preliminary development and evaluation of cost-effective, environmentally acceptable remedial actions.

1.2 OVERVIEW OF REPORT

This report is the result of the remedial investigation conducted from April 1, 1986 to March 10, 1987 at and around the Gould battery recycling facility and secondary lead smelter located in northwest

Portland, Oregon. The main text presents the investigation findings and interpretations; the appendices present the supporting data.

Section 1.0 of this report is introductory. In addition to discussing the purpose and scope of the investigation, relevant background data for the site is presented. A review and summary of the nature and extent of the problem is also included in this section.

Section 2.0 of the report presents results of the site features investigation. Demography, land use, natural resources, and climatology are discussed in this section.

Section 3.0 presents the results of the hazardous substances investigation including waste types, component characteristics, and component behavior. The section contains discussions of how the waste was produced and disposed, and estimates of the amount of different waste constituents. Toxicity and transport behavior are also discussed.

Section 4.0 presents results of the hydrogeologic investigation. Evaluations of site area geology, hydrology, and hydrogeology are presented, in addition to analyses of contaminant transport by ground and surface waters. Section 4.0 differs from the usual remedial investigation report format in that all data for surface and subsurface soil, surface and ground water, and lake and river sediments are integrated into the discussion.

Section 5.0 presents results of the air investigation. Sampling program results, the potential risks associated with sources of airborne lead in the study area, and the migration potential of lead through the airborne pathway are addressed.

Section 6.0 discusses results of the local flora and fauna investigation. Available data on contaminant levels in the local biota is discussed.

Section 7.0 discusses the results of the bench scale and pilot studies. These include battery casing coating tests, batch adsorption, and leach potential tests. The significance of the bench scale and pilot study results on the site's feasibility study is also discussed.

Section 8.0 presents an analysis of public health and environmental concerns. Receptors and pathways to both the human population and environment are assessed in the context of the information presented in Sections 1.0 to 7.0.

References are contained in Section 9.0. Section 10.0 is a glossary of terms used throughout the report.

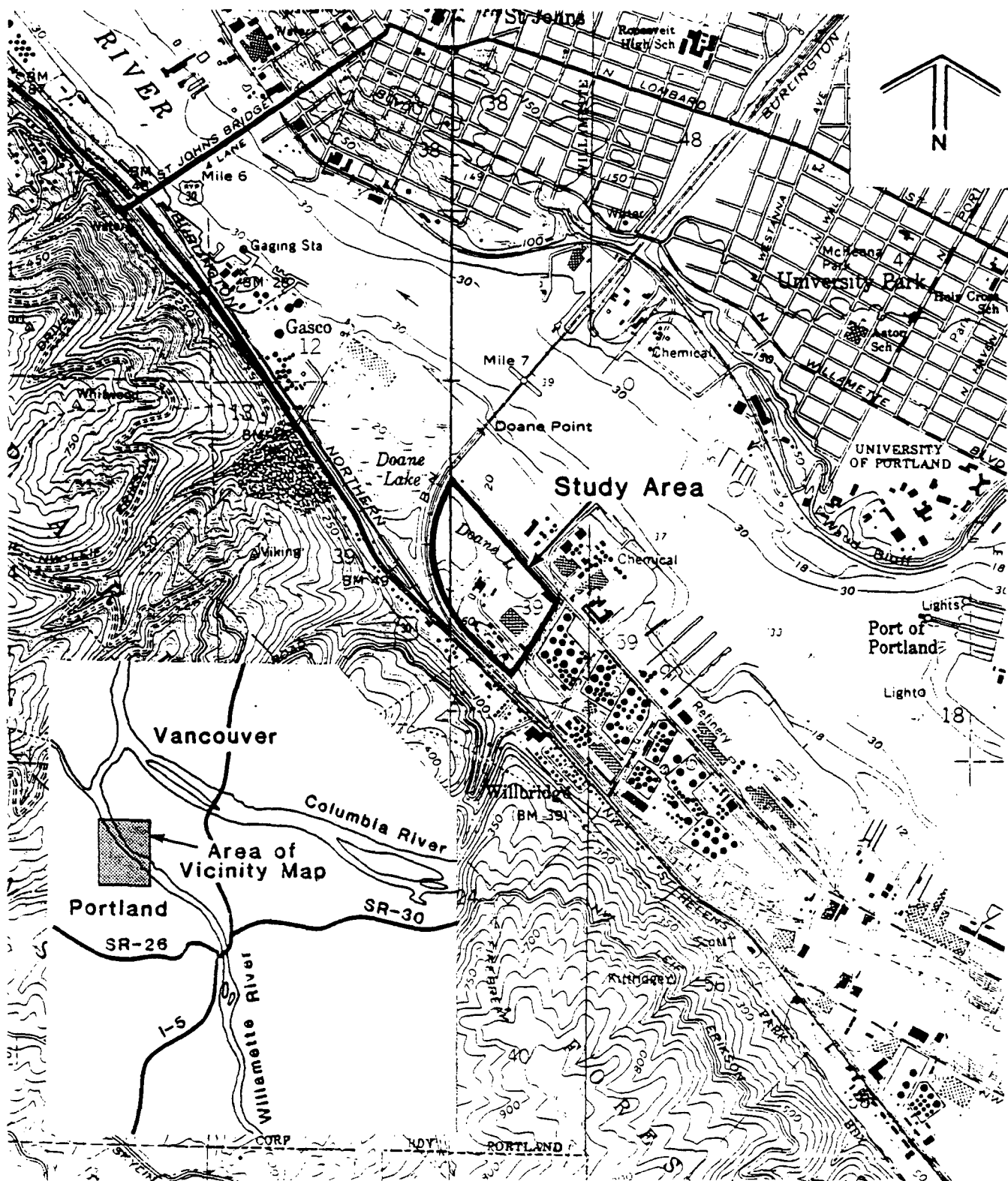
The appendices (Volume II) contain the sampling and analytical procedures (Appendix A), quality assurance/quality control procedures (Appendix B), analytical data (Appendix C), and other data supporting the hydrogeologic investigation (Appendix D), including a discussion of the water budget (Appendix D6).

1.3 SITE BACKGROUND INFORMATION

1.3.1 Site Location and Configuration

The Gould site is located in the Doane Lake area of Portland between N.W. St. Helens Road and N.W. Front Avenue, about 1.3 miles southeast of St. John's Bridge. As shown on Figure 1.3-1 (General Vicinity Map) the Willamette River lies about 1,000 feet to the northeast and flows northwest, parallel to Front Avenue. The area is heavily industrialized. The Gould property encompasses 9.2 acres and is only a portion of the 60-acre study area, as shown on Figure 1.3-2 (Study Area Location Map).

The study area encompasses all of the former (1949) areal extent of Doane Lake. Although it is roughly bounded on the southwest by N.W. St. Helens Road, on the northeast by N.W. Front Avenue, on the southeast by 61st Street, and on the west and northwest by the Burlington Northern railroad right-of-way, the study area was not entirely confined to these boundaries. Industrial properties adjacent to Gould that lie wholly or partly within the study area include American Steel Industries, Inc.; ESCO Corporation; Rhone-Poulenc Inc.; Northwest Equipment Rentals, Inc. (formerly Atlas Wrecking, leased from Rhone-Poulenc); Schnitzer Investment Corporation, Liquid Air Corporation (leased from Schnitzer); and Pennwalt Corporation.



0 0.5 1
SCALE IN MILES

NL IND, INC./GOULD, INC.
REMEDIAL INVESTIGATION

GENERAL VICINITY MAP

FIG. 1.3-1

DAMES & MO

11831-034

SCOEP00004134

1.3.2 Site History

Prior to development (as indicated by aerial photographs taken in 1936 and 1940) the Gould site was a brush and grass-covered landfill that extended into and rose a few feet above Doane Lake. The origin and time of placement of this fill material is unknown. An aerial photograph taken on June 1, 1948, shows the presently existing railroad spur coming onto the western edge of the plant site. The secondary lead smelting facility was completed and went into operation in 1949 under the ownership of Morris P. Kirk and Sons (Kirk & Sons), a subsidiary of NL Industries, Inc. At that time, a significant portion of the site was still occupied by Doane Lake. Subsequent expansion consisted of a warehouse constructed in 1950 and a lead oxide building constructed in 1965. Facility operations consisted of lead-acid battery recycling, lead smelting and refining, zinc alloying and casting, cable sweating (removal of lead sheathing from copper cable), and (after 1965) lead oxide production. A more detailed discussion of placement of fill/waste on the site is presented in Section 3.2.2.2.

Available Oregon Department of Environmental Quality (DEQ) records for the period between February 1960 and January 1970 indicate that Kirk & Sons received 14 complaints and/or violations regarding emissions from the facility. A January 29, 1970 report by the Columbia-Willamette Air Pollution Authority expressed concern over levels of lead in the vicinity of Morris P. Kirk, and the potential threat to health caused by continued plant operations.

When NL Industries purchased the property from the subsidiary in 1971. Three violations of excessive emissions were recorded in 1972. Lead was detected in Doane Lake in 1973, and NL Industries was cited for improper wastewater discharge into the lake. On July 30, 1973, NL Industries curtailed all smelting operations, but the lead oxide still, cable sweater, and refining kettles continued to operate. Available records indicate that the facility operated in compliance with DEQ guidelines during 1974 through 1976.

The property was sold by NL Industries to Gould Inc. in January 1979. In October of the same year, Gould stopped receiving lead-acid batteries, but continued to process a substantial existing stockpile of batteries. In January 1980, lead refining operations were discontinued. Battery decasing operations ceased on April 1, 1981, lead oxide production ceased in May 1981, and the facility closed entirely in August 1981. By the summer of 1982, most of the structures, facilities, and equipment had been removed.

Alchem Western, Inc., began setting up equipment on the Gould property in late 1983 for the purpose of washing, separating, and reclaiming plastic fragments and lead oxide. Battery casing fragments were dredged from the Doane Lake remnant on the northeast portion of the Gould site and stockpiled along the shoreline. These surface debris piles have since remained at this location. After a brief period of activity, Alchem Western suspended operations due to mechanical problems (Moore 1986a). Although most of the Alchem Western equipment has been removed, some still remains on the Gould property at the date of this report.

A historical sequence of significant events and actions related to the battery recycling and secondary lead smelting facility is presented in Table 1.3-1. The Doane Lake landfill, waste debris types, disposal locations, and hazardous material volumes, are discussed in Section 3.2.

1.3.3 Site Topography and Physiography

The study area occupies a section of flat floodplain between the Willamette River and steep slopes of the Tualatin Mountains (locally known as the Portland Hills). Site elevations range between 26 and 48 feet (City of Portland datum¹), with the most abrupt elevation changes occurring along the northwestern boundary of the study area (adjacent to the Doane Lake remnant) and near the pump station on N.W. Front Avenue (see Figure 1.3-3).

¹All elevations in this report refer to the City of Portland datum, which is 1.375 feet below mean sea level.

TABLE 1.3-1

CHRONOLOGICAL HISTORY OF GOULD SITE OPERATIONS

Sheet 1 of 5

1936 & 1940	Aerial photographs (no exact date) show the secondary lead smelting site as a vacant grassy landfill projecting into and rising only a few feet above Doane Lake. The date and source of the pre-1936 landfill are unknown.
June 1, 1948	Aerial photograph shows railroad spur coming into the proposed plant site. No other construction is evident yet.
1949	Secondary lead smelting facility constructed and operated by Morris P. Kirk and Sons (Kirk & Sons). At this time, NL Industries owned 51 percent of Morris P. Kirk (Moore 1986).
1950	Lead oxide building constructed by Kirk & Sons.
Feb. 4, 1960	Complaint mentioned in Oregon Department of Environmental Quality (DEQ) files against Kirk & Sons, regarding burning of battery casings.
1965	A lead oxide production facility was constructed and began operations.
1966	Kirk & Sons initiated a respirator program for employees.
April 14, 1966	The Air Quality Control Division (AQC) of the Portland Bureau of Health recommended taking ambient air lead samples around the Kirk & Sons facility.
July 7, 1966	The AQC observed heavy emissions of yellow dust for 10 minutes around the Kirk & Sons facility.
Dec. 15, 1966	The AQC observed the baghouse stack emitting an opacity reading of 2 to 3 on the Ringelman scale.
Jan. 24, 1967	The AQC reported a 27-minute opacity violation from a 30-minute observation; grayish smoke emission from smelter stack.
Sept. 6, 1967	The AQC reported a 21-1/4-minute opacity violation from a 27-minute observation, white metal fumes and smoke from the blast furnace baghouse stack. The AQC recommended a first notice letter being sent to Kirk & Sons with steps to prevent recurrence of emissions.
Oct. 12, 1967	The Portland Regional Air Pollution Authority noted a 17-minute opacity violation from a 20-minute observation; white to brown smoke from a baghouse stack.

TABLE 1.3-1 (Continued)

Sheet 2 of 5

Oct. 13, 1967	The AQC observed an opacity violation from the baghouse stack at 16:00 to 16:45 hours.
Oct. 21, 1967	The Portland Regional Air Pollution Authority reported a 27-minute opacity violation from a 30-minute observation; smoke from baghouse stack.
Dec. 26, 1968	The Columbia-Willamette Air Pollution Authority reported a 30-minute violation from a 30-minute observation; smoke and flames from lead sweat furnace stack.
March 31, 1969	The Columbia-Willamette Air Pollution Authority noted a 15-minute violation from a 15-minute observation; smoke from baghouse exhaust stack.
Nov. 14, 1969	Kirk & Sons corrected baghouse emissions from melting kettle and blast furnace.
Jan. 29, 1970	The Columbia-Willamette Air Pollution Authority calculated lead emissions from the Kirk & Sons facility and concluded: "It is apparent that levels of lead in the vicinity of Morris P. Kirk can cause a definite threat to health and should not be allowed to continue."
March 16, 1970	The Columbia-Willamette Air Pollution Authority observed a 16-minute violation from a 16-minute observation; yellow particulates from lead furnace baghouse exhaust.
June 17, 1970	The Columbia-Willamette Air Pollution Authority observed a 5-minute violation from 30-minute observation; gray smoke from stack.
1971	NL Industries purchased the property from their subsidiary, Morris P. Kirk & Sons. Also, this same year battery manufactures began using plastic for casings.
March 16, 1972	The Columbia-Willamette Air Pollution Authority observed a 30-minute violation from a 30-minute observation; white air contaminants from baghouse exhaust. Notice of violation sent to NL Industries; no penalty levied.
Aug. 16, 1972	The Columbia-Willamette Air Pollution Authority noted emissions but recorded no measurements.

TABLE 1.3-1 (Continued)

Sheet 3 of 5

Sept. 27, 1972	The Columbia-Willamette Air Pollution Authority recorded a 49-minute violation from a 60-minute observation; white smoke from baghouse stack. Notice of violation issued, no penalty levied.
March 12, 1973	The DEQ sampled NL facility discharge into Doane Lake; test results indicated 9.5 and 10.3 ppm lead.
March 19, 1973	NL Industries cited for wastewater discharge to Doane Lake.
April 30, 1973	The Columbia-Willamette Air Pollution Authority requested that NL Industries provide a compliance schedule to control emissions from the blast furnace before issuing a new Air Contaminant Discharge Permit. Monitoring and reporting provisions were also a requirement.
July 30, 1973	NL Industries curtailed all smelting operating and remodeled the Portland facility to function as a transfer point to ship and receive goods from Los Angeles. The lead oxide still, cable sweater, and refining kettles continued to operate.
Nov. 6, 1974	Inspection by DEQ indicated that NL Industries were in compliance with their Air Contaminant Discharge Permit.
Jan. 19, 1976	Inspection by DEQ indicated that NL Industries were in compliance with their Air Contaminant Discharge Permit.
Oct. 1976	Violations for wastewater discharge by NL Industries were corrected.
Jan. 16 & 30, 1978	NL Industries sent two loads of acid waste to a hazardous waste management facility in Arlington, Oregon for disposal.
Aug. 15, 1978	Doane Lake (east remnant) sampled by DEQ; test results indicated 0.1 and 0.3 ppm lead.
Jan. 1979	Gould Inc. purchased the facility from NL Industries.
Oct. 1979	Gould stopped receiving lead-acid batteries for recycling and concentrated on reducing their on-site stockpile.
Nov. 8, 1979	Preliminary modeling analysis by DEQ suggested Gould may be violating the new ambient lead standard for the lead trailer loading operation.

TABLE 1.3-1 (Continued)

Sheet 4 of 5

Jan. 1, 1980	Gould began neutralizing waste acid with ammonia and discharging it into the City sanitary sewer system.
Jan. 1980	Gould terminated lead refining operations.
March 5, 1981	DEQ issued notice to Gould of discharge violations and creating offensive conditions. A medium-rate civil penalty was recommended.
April 1, 1981	Gould terminated battery decasing operation.
April 28, 1981	DEQ obtained two yards cleaning samples; EP leachate test results indicated 280 and 4,200 ppm lead.
May 1981	Gould terminated lead oxide production.
June through Sept. 1981	Ambient air monitoring at the Gould facility by DEQ.
July 10, 1981	DEQ sent notice to Gould of intent to assess civil penalties.
Aug. 1981	Gould facility ceased all operations.
Oct. 30, 1981	DEQ requested that Gould undertake a comprehensive cleanup program.
Jan. 21, 1982	Dames & Moore began field work on initial monitoring wells.
Feb. 12, 1982	Gould sold plant equipment and buildings.
July 9, 1982	DEQ requested a cleanup program from Gould.
July 22, 1982	DEQ decided no cleanup of the Gould site was warranted by the ground-water data received to date.
Aug. 1982	Dames & Moore conducted one week of ambient air monitoring at the Gould facility.
Sept. 24, 1982	DEQ requested that Gould submit a schedule for removing the battery cases from the site and for sampling soil and pond sediments on the site.
Oct. 26, 1982	Gould responded to DEQ request, indicating that they would level and cover the battery casings.

TABLE 1.3-1 (Concluded)

Sheet 5 of 5

Dec. 3, 1982	DEQ rejected Gould's plan for covering the battery casings.
Feb. 25, 1983	Gould Inc. submitted a letter to EPA objecting to EPA's Hazard Ranking System (HRS) score for the site. The score had been used by EPA to propose inclusion of the site on the NPL. In particular, the Gould letter objected to the methods used to determine airborne contaminant hazards at the site.
Dec. 31, 1983	Alchem Western moved battery casing recovery equipment to the Gould facility.
Jan. 28, 1984	The Alchem Western equipment operated for one day before experiencing bearing failure. Operations were discontinued and not reinitiated.
Aug. 30, 1985	Gould Inc. and NL Industries signed Section 106, Administration Order on Consent for the Remedial Investigation/Feasibility Study (RI/FS) of the facility.
April 1, 1986	Work Plan for RI/FS by Dames & Moore was approved and site investigations began.
June 1, 1987	Draft RI report was submitted to agencies.
July 29, 1987	Review comments on Draft RI report received from agencies.

Agency files reviewed: The Oregon Department of Environmental Quality (DEQ) and U.S. Environmental Protection Agency (EPA).

The DEQ was formed in 1969 and it replaced the Oregon Sanitary Authority, which began around 1939. From late 1967 to about 1973, the Portland Regional Pollution Authority and the Columbia-Willamette Air Pollution Authority were in existence, but they eventually merged into the DEQ. The Federal Water Pollution Control Administration became the U.S. EPA about 1970.

2.0 SITE FEATURES INVESTIGATION

The purpose of this section is to provide a framework for assessing existing and potential threats to human health and the environment as a result of site contamination. This portion of the remedial investigation report includes discussions of the demography, land use, natural resources, and climatology of the subject site and adjacent area. The study area includes property owned or leased by Gould Inc., American Steel Industries, Inc., ESCO Corporation, Rhone-Poulenc Inc., Northwest Equipment Rentals, Inc. (formerly Atlas Wrecking, leased from Rhone-Poulenc), Schnitzer Investment Corporation, Liquid Air Corporation (leased from Schnitzer), and Pennwalt Corporation. Properties adjacent to the study site area (Figure 1.3-2) are discussed in the demographic, land use, and natural resources portions of this report.

2.1 DEMOGRAPHY

2.1.1 Population

In general, the Gould site is located in an area which is less densely populated than surrounding areas to the northeast and southeast. The site is located in census tract 43, a large tract which parallels the Willamette River for approximately 7 miles. The 1985 population for all of tract 43 was 903 persons, a decrease of seven persons from the 1980 population of 910 (METRO 1985).

By way of contrast, the population of census tract 40.02 represents the more densely populated areas near the Gould site. Census tract 40.02 is approximately 1 mile square, and is located approximately 1/2 mile northeast of the Gould site across the Willamette River. The 1985 population of census tract 40.02 was 4,812 persons, a decrease of almost 100 persons from the 1980 population of 4,911 (METRO 1985).

The 1986 population for the entire City of Portland totals approximately 422,000 persons.

2.1.2 Employment

Industrial and commercial businesses in the vicinity of the study area employ a few hundred people. Rhone-Poulenc has 40 employees; American Steel Industries has 48; Liquid Air has three; Pennwalt has 170; and Gould has one. Northwest Equipment Rentals, the wrecking yard on Rhone-Poulenc property adjacent to Gould, employs two to five permanent employees plus seasonal help.

2.1.3 Housing

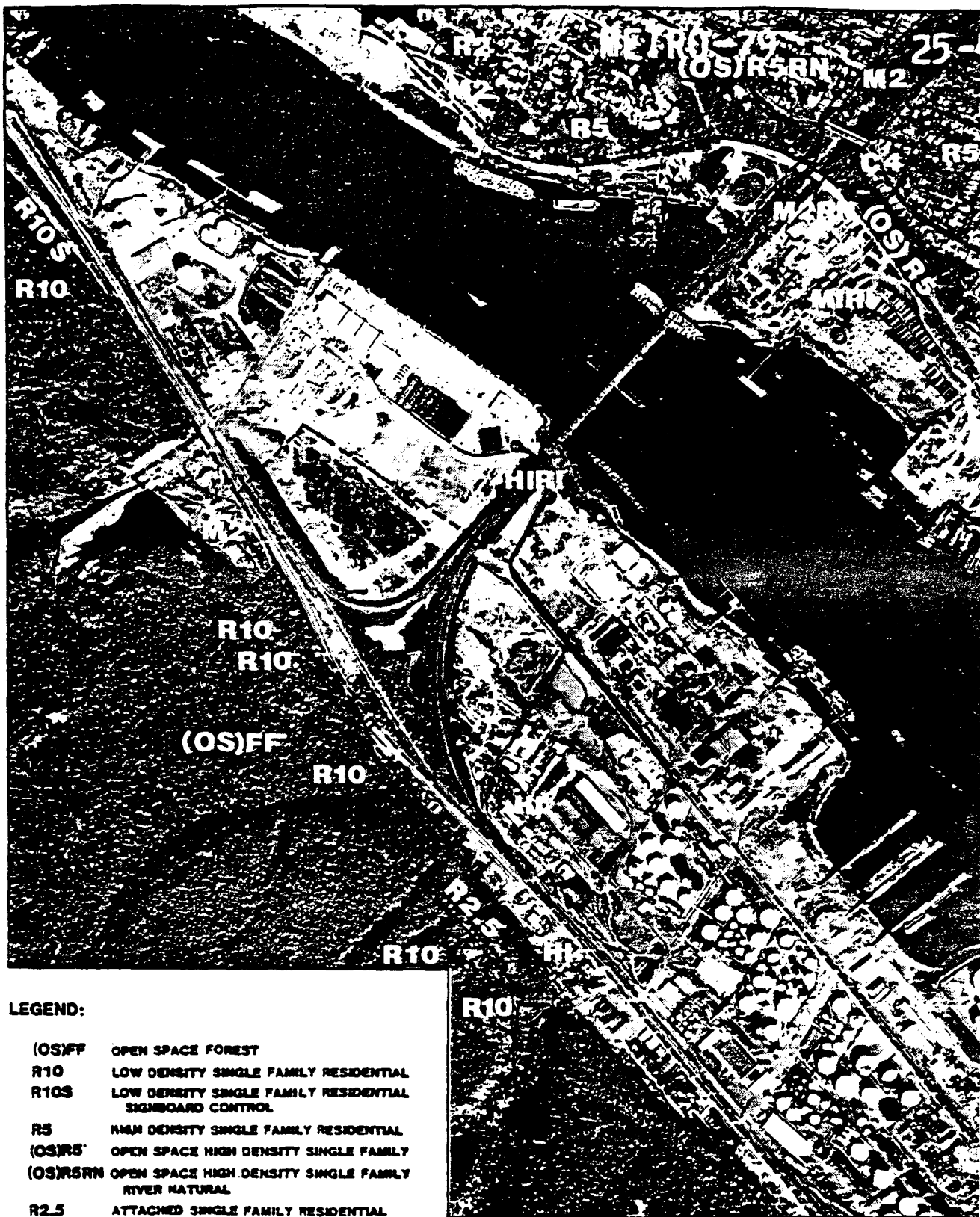
There are no private residences within the immediate study area. A few widely scattered private residences and rental units are located in a narrow zone between N.W. St. Helens Road and Forest Park, south and west of the study area (Figure 2.1-1). The 1985 census data for all of Census Tract 43 shows a total of 425 dwelling units, 380 of which are single family homes (METRO 1985).

The nearest zone of dense housing lies across the Willamette River to the north and northeast, some 3,000 to 3,800 feet from the study area (Figure 2.1-1). The 1985 census data for a portion of this area (Census Tract 40.02) shows a total of 1,736 dwelling units, 1,569 of which are single family homes (METRO 1985).

2.2 LAND USE

2.2.1 Existing Land Use

The existing land use in the study area and vicinity is primarily industrial, and generally follows the City of Portland zoning code designations (Figure 2.1-1). The area between Forest Park and St. Helens Road contains a few residential buildings, even though the area is zoned for heavy industrial use. The nearest large area of residential land use is on the east side of the Willamette River. Forest Park, west of St. Helens Road, is largely undeveloped but does contain a few scattered residences along its eastern portion. The current City of Portland zoning code designations are shown in Figure 2.1-1, overlain on an aerial photograph of the site dated October 1979. Present-day land use has remained essentially unchanged since that date.



LEGEND:

(OS)FF	OPEN SPACE FOREST
R10	LOW DENSITY SINGLE FAMILY RESIDENTIAL
R10S	LOW DENSITY SINGLE FAMILY RESIDENTIAL SIGNBOARD CONTROL
R5	MEDIUM DENSITY SINGLE FAMILY RESIDENTIAL
(OS)R5	OPEN SPACE HIGH DENSITY SINGLE FAMILY
(OS)R5RN	OPEN SPACE HIGH DENSITY SINGLE FAMILY RIVER NATURAL
R2.5	ATTACHED SINGLE FAMILY RESIDENTIAL
R2	LOW DENSITY MULTI FAMILY RESIDENTIAL
C4	NEIGHBORHOOD COMMERCIAL
M2	GENERAL MANUFACTURING
M2RN	GENERAL MANUFACTURING RIVER NATURAL
MIRI	HEAVY MANUFACTURING RIVER INDUSTRIAL
HI	HEAVY INDUSTRY
HIRI	HEAVY INDUSTRY RIVER INDUSTRIAL

NL IND, INC./GOULD, INC.
REMEDIAL INVESTIGATION

EXISTING LAND USE AND
ZONING CODE DESIGNATIONS

FIG. 2.1-1

DAMES & MOORE

11831-034

SCOEP00004144

2.2.2 Planned Land Use

No significant changes in the area's existing land use patterns (as indicated on Figure 2.1-1) are presently planned. The range of future uses for the site is being considered in preparation of the Feasibility Study.

2.2.3 Land Use Plans and Controls

The study area and adjacent areas have been divided by the City of Portland Planning Bureau into 15 zones shown (Figure 2.1-1). A summary of the Portland zoning code designations applicable to the site is given in Table 2.2-1. The City is presently in the process of changing the zoning code designation for areas near the Willamette River (City of Portland 1987). The zoning code changes are only designation changes and will have no effect on allowable land use. The designation changes are shown on Table 2.2-2.

In planning and zoning for the area immediately adjacent to the Willamette River, the City is restricted by the State of Oregon Greenway Statute (Oregon Revised Statute 390). The statute was written by the Oregon Legislature in 1973 to "protect and preserve the natural, scenic and recreational qualities of lands along the Willamette River". The statute allows each municipality along the river to develop their own land use plans as long as they follow the general goal of the statute. The City of Portland has developed a plan that preserves the river-dependent and river-related industrial development and establishes public access to the river (City of Portland 1986).

2.3 NATURAL RESOURCES

2.3.1 Vegetation

The Gould plant site occupies a flat area between the Willamette River on the east and the forested slopes of the Tualatin Mountains to the west. The site is currently paved with asphalt and is basically

TABLE 2.2-1

SUMMARY OF APPLICABLE ZONING CODE DESIGNATIONS

FARM AND FOREST ZONE

FF Farm and Forest: Allows agriculture, forest and single-family homes on lots of two acres or larger.

SINGLE-FAMILY RESIDENTIAL ZONES

R10 Low-density single-family residential: Allows one house on a 10,000 square-foot lot.

R5 High-density single-family residential: Allows one house on a 5,000 square-foot lot.

R2.5 Attached single-family residential: Allows construction of attached units with an average lot area of 2,500 square feet per lot.

MULTI-FAMILY RESIDENTIAL ZONE

R2 Low-density multi-family residential: Allows single-family and row houses, duplexes, apartments and condominiums at a density of one unit per 2,000 square feet of site area.

COMMERCIAL ZONE

C4 Neighborhood commercial: Allows small neighborhood service commercial businesses with a maximum floor area of 4000 square feet. If extra conditions are met up to 7000 square feet may be permitted.

INDUSTRIAL ZONES

M2 General manufacturing: Allows light and general industrial uses. Commercial uses are restricted, and new housing is not permitted.

M1 Heavy manufacturing: Allows manufacturing and industrial uses. Commercial uses are restricted, and new housing is not permitted.

HI Heavy industrial: Allows general and heavy industrial uses. Most commercial uses are restricted. New residential uses are not permitted.

OVERLAY ZONE

S Signboard control: Restricts and regulates signs near bridges and certain highways.

WILLAMETTE RIVER OVERLAY ZONES

Selected designations related to public access, open space and land use along the Willamette River

RI River Industrial
RD River Development
RR River Recreational
RN River Natural

TABLE 2.2-2

CITY OF PORTLAND ZONING CODE DESIGNATION CHANGES

<u>OLD DESIGNATION</u>	<u>NEW DESIGNATION</u>
Willamette Industrial (WI)	River Industrial (RI)
Willamette Scenic Development (WSD)	River Development (RD)
Willamette Scenic Recreational (WSR)	River Recreational (RR)
Willamette Natural (WN)	River Natural (RN)

Source: City of Portland 1987

devoid of natural vegetation. The vegetation that exists is mostly brush, small trees, and blackberries along the property fenceline. A few evergreen trees are located near the office building. Some vegetation exists along most of the east Doane Lake remnant shoreline, but is absent next to the plant site where battery casing fragments are present.

The Tualatin Mountains, which rise directly southwest of the site, are characterized by second-growth forests of Douglas fir (Pseudotsuga menziesii) and western hemlock (Tsuga heterophylla). Deciduous trees such as big-leaf maple (Acer macrophyllum), alder (Alnus rubra), Oregon ash (Fraxinus oregona), cottonwood (Populus trichocarpa), vine maple (Acer circinatum), and cascara (Ramnus purshiana) probably occur on these slopes (Franklin and Dyrness 1973). Common understory shrubs should include salal (Gaultheria shallon), Oregon grape (Berberis nervosa), devil's club (Echinopanax horridum), and salmonberry (Rubus spectabilis) (Franklin and Dyrness 1973).

2.3.2 Wildlife

Occurrence of animals at the site is low, since the habitat necessary to support onsite fauna is limited. Common animal species that have been seen onsite include ground squirrels (probably Otospermophilus beechyi), mallards (Anas platyrhynchos) that are resident on the pond, and passerine bird species that feed in the brushy, weedy areas around

the site perimeter (Moore 1986b). A bobcat (Lynx rufus) has reportedly been seen near the site in the vicinity of Doane Lake on a regular basis (Moore 1986b). It undoubtedly resides in the mountains west of the site. Blacktail deer (Odocoileus hemionus) are also occasionally sighted outside the fenced area. A red fox has also been spotted on the Rhone-Poulenc property.

2.3.3 Aquatic Resources

It is doubtful that any fish reside in either remnant since natural water sources and discharges are limited. During field sampling activities, numerous aquatic insects and frogs were observed in the West Doane Lake remnant. None were observed during concurrent sampling in the East Doane Lake remnant, although frogs reportedly have been seen in East Doane Lake.

Numerous fish species reside in or migrate through the lower reach of the Willamette River in the vicinity of the site (Oregon Department of Fish and Wildlife 1972, 1986). These species (and their status as resident or migrant species) are listed in Table 2.3-1.

2.3.4 Rare, Threatened, or Endangered Species

No state or federally designated rare, threatened, or endangered species are known to inhabit the site.

2.3.5 Sensitive Species or Habitats

No sensitive species are known to inhabit the site. The Willamette River flows approximately 1,000 feet northeast of the site and could be considered a sensitive habitat. This area of the Willamette River is near its confluence with the Columbia River. Substantial waterfowl and other bird groups use the lower Columbia River for feeding, nesting, and resting. The Willamette River is also a migratory corridor for several anadromous fish species.

TABLE 2.3-1

FISH SPECIES IDENTIFIED FROM THE WILLAMETTE RIVER
IN THE VICINITY OF THE NL/GOULD SITE

<u>SPECIES</u>	<u>STATUS</u>
Chinook Salmon (<u>Oncorhynchus tshawytscha</u>)	Spring and fall migrant
Coho Salmon (<u>Oncorhynchus keta</u>)	Migrant
Steelhead (<u>Salmo gairdneri</u>)	Summer and winter migrant
American Shad (<u>Alosa sapidissima</u>)	Migrant
Largemouth Bass (<u>Micropterus salmoides</u>)	Resident
Smallmouth Bass (<u>Micropterus dolomieu</u>)	Resident
Crappie (<u>Pomoxis</u> sp.)	Resident
Bluegill (<u>Lepomis macrochirus</u>)	Resident
Walleye (<u>Stizostedion vitreum vitreum</u>)	Resident
Northern Squawfish (<u>Ptychocheilus oregonensis</u>)	Resident
Catfish (<u>Ictalurus</u> sp.)	Resident
Mountain Whitefish (<u>Prosopium williamsoni</u>)	Resident
Carp (<u>Cyprinus</u> sp.)	Resident
Sucker (Catostomidae)	Resident
Peamouth (<u>Mylocheilus caurinus</u>)	Resident
Chiselmouth (<u>Acrocheilus alutaceus</u>)	Resident

Source: Oregon Department of Fish & Wildlife 1972, 1986.

2.3.6 Parks and Recreation Areas

Forest Park lies southwest of the site in the Tualatin Mountains. Its northwestern boundary lies within about 350 feet of the study area. The park is very large, however, encompassing some 4,700 acres in an area 8 miles long by 1 mile wide. Much of the park has limited access and low public use. This is especially true for portions nearest the study area. A public boat launch is located underneath St. John's Bridge, approximately 1 mile downstream of the site.

2.3.7 Natural Resource Development

Traditional natural resource development (timber harvest, mineral extraction, or water use) has virtually no potential within the near vicinity of the site. Much of the surrounding area has been previously developed for industrial uses.

2.4 CLIMATOLOGY

2.4.1 Regional Weather Patterns

The Pacific Ocean is the single most important geographic feature of the climate in western Oregon. The unlimited supply of moisture available to airmasses that move across the Pacific Ocean is largely responsible for the abundant rainfall over the western part of the state. Portland is situated about 65 miles inland from the Pacific Coast.

Two mountain ranges which run the full north-south length of the state exert an important influence on weather in the Portland region. The Coast Range, rising between 2,000 and 3,000 feet above sea level, provides limited shielding to the Portland area from the Pacific Ocean. The Coast Range forms the western boundary of the broad Willamette Valley and runs in a northerly direction about 30 miles west of Portland.

The Cascade Range, which parallels the Coast Range, is located approximately 30 miles east of Portland. The Cascades rise from the eastern edge of the Willamette Valley to an average height of about 5,000 feet above sea level. They provide a steep slope for topographic lift of moisture-laden, westerly winds which result in moderate rainfall. These mountains also form a barrier against continental airmasses which originate over the interior Columbia Basin to the east. The Columbia Gorge winds through the rugged Cascade Range. Portland is located near the confluence of the Columbia and Willamette rivers and river basins.

Airflow is usually northwesterly in the Portland area in spring and summer, and southeasterly in fall and winter. This pattern is interrupted infrequently by winds of dry continental air moving westward through the Cascade passes. The winter season is marked by relatively mild temperatures, cloudy skies and rain with southeasterly surface winds predominating. Summer produces mild temperatures, northwesterly winds and very little precipitation. Fall and spring weather patterns are transitional in nature.

Fall and early winter experience the highest incidence of fog. Portland experiences about 34 days per year when fog reduces visibility to less than one quarter mile (Ruffner 1985). In all seasons, incursions of coastal marine air are a frequent moderating influence. Outbreaks of continental high pressure from east of the Cascades produce strong easterly flow through the Columbia Gorge into the Portland area. In winter, this brings the coldest weather with the extremes of low temperature registered in the cold airmass.

2.4.2 Local Climate

The United States Weather Service Station in Portland is located at Portland International Airport, six miles north-northeast of downtown Portland. This location is about six miles east of the Gould property. Climatological data collected at this station is generally representative of weather conditions at the site.

2.4.2.1 Wind

Destructive storms are infrequent in the Portland area. Surface winds seldom exceed gale force, although several times each year winds reaching hurricane forces of 74 miles per hour (mph) and over strike the coast. These winds sometimes move inland to the western valleys and up the Columbia Gorge. The few tornados reported have been short-lived.

The prevailing wind direction in the Portland area is strongly influenced by the surrounding terrain. In the Columbia Gorge, the prevailing wind direction follows the orientation of the gorge at that point. Similarly, prevailing wind directions in the Willamette Valley

are aligned north-south with the valley. Very strong winds are determined by the direction of the major storm movements, and tend to be from the south or west. Light winds greatly outnumber the strong winds, with mountain slopes and other topographic features influencing their direction.

Mean wind speed at the Portland airport varies from about 6.5 mph during September and October to 10.1 mph during January. The annual mean wind speed is 7.9 mph (Ruffner 1985).

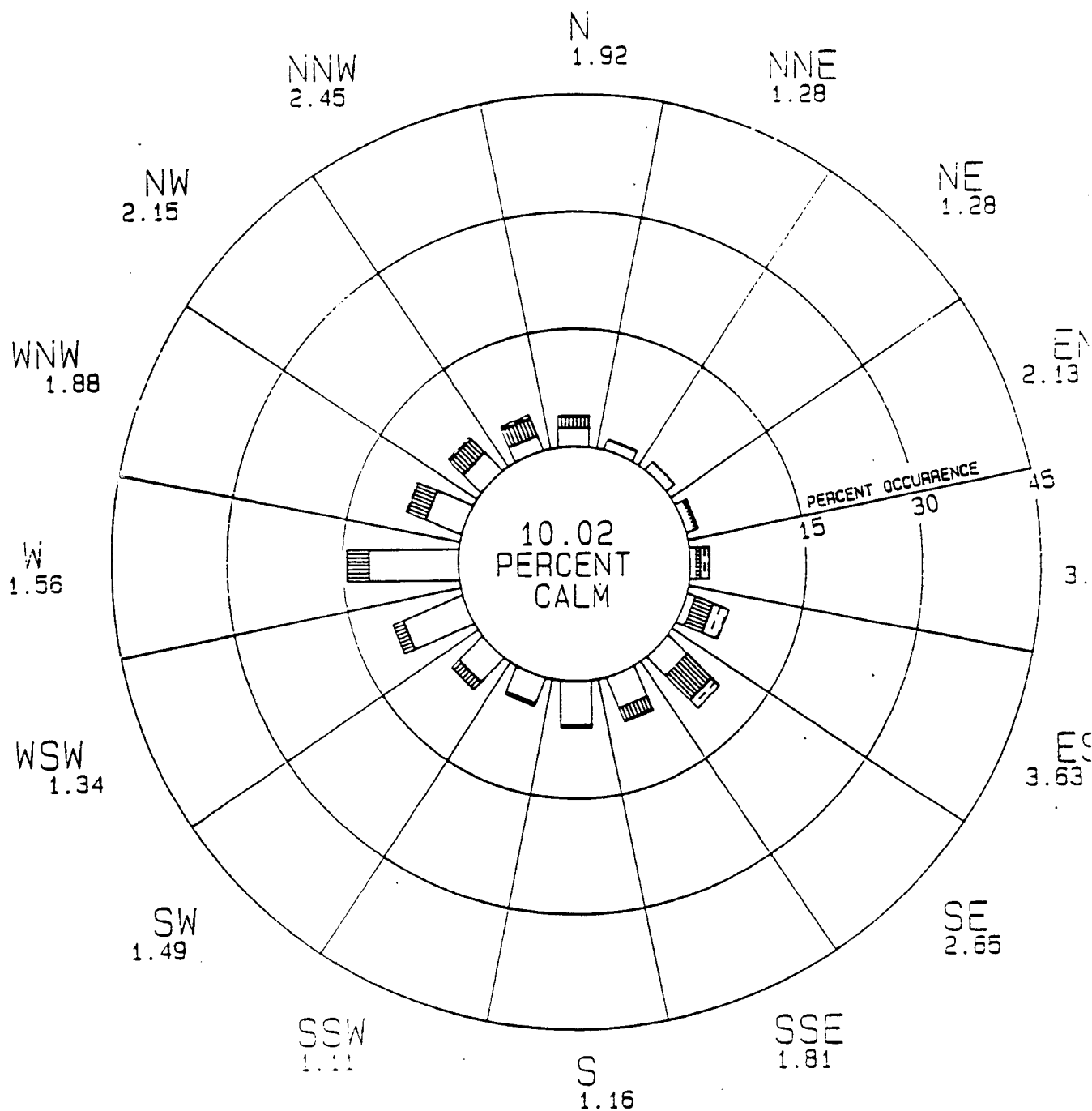
Wind direction at the NL/Gould site is strongly influenced by the topographic feature of the hillside southwest of the site. Resulting wind directions tend to be west-southeast along the Willamette River. A wind rose for a wind monitoring station, located next to the NL/Gould site for the period February 1977 through August 1980, is shown in Figure 2.4-1.

2.4.2.2 Temperature

Normally, temperatures in the Portland area are mild. Hot, dry continental airmasses moving westward down the Columbia Gorge bring the highest summer temperatures. The highest recorded temperature in Portland was 107° Fahrenheit (F). The continental airmasses moving down the Columbia Gorge also bring the coldest weather in winter. The lowest recorded temperature in Portland was -3°F.

On average, only ten days per year experience maximum daily temperatures greater than 90°F. The average maximum daily temperature for the year is 62°F. Maximum daily temperatures average from 79.5°F in July to 44.3°F in January. On average, the maximum daily temperature is less than 32°F only four days per year.

The average minimum daily temperature for the year is 44°F. Minimum daily temperatures vary from 55.8°F in July and August to 33.5°F in January. Approximately 43 days per year experience minimum temperatures below 32°F (Ruffner 1985).



NUMBERS INDICATE SECTOR MEAN WIND SPEED

WIND SPEED RANGE

	0 - 2	M/S
	2 - 4	
	4 - 8	
	8 - 12	
	>12	

SOURCE:

OREGON DEPT. OF ENVIRONMENTAL QUALITY

NL IND, INC./GOULD, INC.
REMEDIAL INVESTIGATION

WIND FREQUENCY DISTRIBUTION
STANDARD OIL SITE

FEB. 5, 1977 TO AUG. 29, 1980

FIG. 2.4-1

DAMES & MOORE

11831-034

2.4.2.3 Precipitation

Portland has a very definite winter rainfall climate. Approximately 88 percent of the total annual precipitation occurs in the months of October through May, 9 percent in June and September, and only 3 percent in July and August. There are an average of 227 cloudy days per year in Portland.

Precipitation in the Portland area is mostly rain. Average rainfall is 37.39 inches. Monthly averages vary from 0.46 inches in July to 6.41 inches in December. The maximum monthly rainfall on record for the Portland area was 20.14 inches in December 1982. On average, there are only 5 days per year with measurable snow. The snowfall is seldom more than a few inches; the greatest amount measured on record was 16 inches (Ruffner 1985).

2.4.2.4 Evapotranspiration

There are no known quantitative data on transpiration for grasslands in the vicinity of the Gould site. Transpiration from the site is judged to be very low because of the lack of vegetation, other than grasses. Indeed, onsite grasses have very patchy distribution except in the area of the "clay cap" placed on the ESCO property.

Evaporation data are not collected by the Weather Bureau in Portland. United States Geological Survey (USGS) has used data from Corvallis, Oregon (Hart & Newcomb 1965) to estimate evaporation for Portland, and has used data from Seattle, Washington and Wind River, Washington to estimate evaporation for Vancouver, Washington (Table 2.4-1; Mundorff 1964). As expected, evaporation is high when precipitation is low and vice versa. Thus, evaporation will have minimal effect on recharge.

TABLE 2.4-1

AVERAGE TOTAL EVAPORATION
IN WESTERN WASHINGTON

LOCATION	TOTAL EVAPORATION (Inches) ¹											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
Maple Leaf Reservoir, Seattle	0.50 ²	0.59	1.76	2.91	4.40	4.77	8.28	4.97	3.25	1.55	0.85	0.53
Wind River (Skamania County)	--	--	--	3.20	4.86	5.55	7.07	6.82	3.50	1.57	--	--

1) Measured in Standard Weather Bureau Class A land pan, 4-foot diameter.

2) Estimated by Mundorff (1964).

-- Indicates data are not available.

Source: Mundorff (1964)

The former Doane Lake has been filled over the years until only two remnants remain in the study area (Figure 1.3-2). The West Doane Lake remnant is adjacent to the railroad tracks along the northwestern boundary of the study area. It has an average surface elevation of about 26.5 feet and is dammed at the north end. There is no overflow pipe or channel. The East Doane Lake remnant lies on or adjacent to property owned by Gould Inc.; Schnitzer Investment Corporation; and American Steel Industries. It has an average surface elevation of about 28.0 feet (City of Portland datum). At approximately 30.5 feet, the east remnant overflows and drains into a storm drain catch basin located along N.W. Front Avenue. The storm drain catch basin drains directly to the Willamette River.

1.3.4 Other Information

A map of the Gould property (Figure 1.3-4) shows the plant layout as it was when Gould purchased the facility from NL Industries in 1979. Plant conditions had changed little since it was first constructed by Kirk & Sons in 1948. Exceptions are the additions of the warehouse in 1950 and the lead oxide facility in 1965.

Gould property conditions as they currently exist are shown on Figure 1.3-4. The only structures that currently remain on the property are the field office and cafeteria/welfare building, as indicated on Figure 1.3-4. Although the paved area has remained essentially unchanged since 1979, some additional fill material has been placed into the East Doane Lake remnant since that time. Piles of battery casing fragments, containing metallic lead and lead oxide, exist along the southern edge of this remnant. Additional debris, wastes deposited by adjacent industries, lies buried on and off the Gould property. Composition of this debris includes hydrated lime, construction debris, and automobile interiors.

Properties other than Gould that make up portions of the study area include Rhone-Poulenc Inc.; Liquid Air Corporation; Pennwalt Corporation; Schnitzer Investment Corporation; ESCO Corporation; and American Steel Industries, Inc. (see Figure 1.3-2). The chemical facility now owned

by Rhone-Poulenc was originally built in 1943 by Chipman Chemical Company. Chipman sold the property to Rhodia, Inc. in 1964. Rhodia, a French firm, eventually became the Rhone-Poulenc Agrochemical Division when the French government nationalized Rhodia several years ago. The firm has changed names from time-to-time, but continues under the ownership of Rhodia to the present time.

The facility, under Chipman, initially produced a herbicide to control vegetation along railroad tracks. Insecticides were produced at the facility in the late 1940s. Production of 2,4-D began in 1956 and ended in 1982. A herbicide known as 2-methol-4-chlorol-phenoxyacetic acid (MCPA) was produced at the facility from 1960 to 1976. Production of 2,4-DB at the facility began in 1963 and ended in 1982. Esters were produced at the facility from 1956 to 1983 and Viromoxynilactanoate from 1971 to the present time.

During the facility's early years of operation by Chipman, production effluent was discharged into Doane Lake. Chlorinization of the effluent was initiated in 1964 and an activated charcoal filter process was added in 1969. Beginning in 1971, treated wastewater was disposed into the City of Portland sewer system. A rainwater collection and treatment facility was constructed in 1977 to intercept surface runoff before it could carry any potential contamination off site. An intermittently operated, ground-water treatment and monitoring system was installed in 1981; a routine system of water level measurements with periodic sampling and testing have been in place since that time.

The ESCO property, adjacent to Gould, was also created by the filling of Doane Lake. Fill materials probably came from a variety of sources. Based on subsurface investigations, it appears to consist principally of foundry sand and slag gravels from an ESCO steel mill located outside the study area. There has been no construction on the ESCO property, with the exception of some underground utilities along N.W. Front Avenue and an electric powerline along the southeastern property line (adjacent to the Gould property).

The Liquid Air facility is located on property leased from Schnitzer Investment Corporation. The plant was constructed between 1940 and 1948

by Industrial Air and later sold to Liquid Air Corporation. It has been expanded from time-to-time. The plant manufactures only acetylene gas, but serves as a distributor for various other industrial gases which they receive in bulk from other sources.

In the production of acetylene gas, calcium carbide and water are combined with hydrated lime as a byproduct. This lime was disposed of in Doane Lake for many years. It was later placed in a holding area separated from the East Doane Lake remnant by a dike. For a time, lime was reclaimed from the lake, but details and dates on this activity are not available. Liquid Air now retains the lime byproduct in storage tanks for resale.

The Portland Pennwalt plant, built in 1941, produces chlorine by electrolytic decomposition of salt (sodium chloride). There is an on-site lagoon for holding brine purification sludge. More hazardous byproducts, such as sodium arsenite, are shipped to a hazardous waste management facility in Arlington, Oregon for disposal (Willamette Week 1985).

American Steel Industries operates a steel warehousing facility adjacent to the Gould property. It was formerly owned by Gilmore Steel. Fill materials were used on the American Steel property as well.

1.4 NATURE AND EXTENT OF THE PROBLEM

1.4.1 Characteristics and Extent of Wastes

Wastes produced by the secondary lead smelting facility consisted of battery casing fragments, sulfuric acid, matte, sweeping and cleaning residues, and off-gases. Disposal methods for these wastes are summarized briefly below, and are discussed in length in Section 3.0.

After the batteries were decased, the casings were sent through a mill that reduced them to coarse fragments. These fragments were then disposed of in Doane Lake on or immediately adjacent to the smelting facility. The locations and quantities of battery casing fragments produced during the life of the facility are discussed in Section 3.2.3.

Test results indicate that the amount of metallic lead plus lead oxide in the battery casing fragments ranges between 3.1 and 14.5 percent.

During most of the life of the facility, the battery acid drained directly into Doane Lake. On January 16 and January 30, 1978, two truck-loads of acid waste were sent to a hazardous waste management facility in Arlington, Oregon for disposal. After January 1, 1980, waste acid was neutralized with ammonia and discharged into the Portland sanitary sewer system. Based on reported production rates, some 6.5 million gallons of battery acid were discharged into Doane Lake between 1949 and 1973 (Section 3.2.4).

Almost 12,000 tons of matte are estimated to have been produced during the life of the facility (Section 3.2.1). This material contains a number of impurities, but is characteristically high in metals such as iron, lead, arsenic, and antimony. All matte was disposed of on-site (Section 3.2.3).

Sweepings and cleaning residue from the zinc melting and alloys process consisted of zinc, copper, and minor amounts of magnesium that were cleaned from the alloy room floor on a daily basis and placed in 55-gallon steel drums. The filled drums were deposited in Doane Lake on the plant site. The total volume of disposal sweepings is unknown, but it was small in comparison to other waste discharges.

Off-gases from the blast and reverberatory furnace, along with dust from the fume hood, were sent through an air pollution control unit called the baghouse. The baghouse was designed to filter the hazardous material emissions before off-gases were released to the atmosphere. During the life of the facility, many violations and/or complaints were received due to excessive baghouse emissions. Based on information in DEQ and EPA files, a list of these violations and complaints is included in Table 1.3-1.

1.4.2 Special Waste Considerations

Other types of waste are described in Section 3.2.2. Special waste considerations for the study area are extremes in pH that were noted in several water samples during the Remedial Investigation, and organics in ground water from off-site sources. Long-term storage of this water in drums or other metallic containers may create corrosion problems. Excavation, removal, or transport of contaminated soil and waste debris is a concern with regard to airborne particulates, particularly lead, and requires special considerations such as dust control, use of adequate personal safety equipment, and containment during off-site transport.

1.4.3 Present Conditions of Materials and Structures

The secondary lead smelting facilities that existed in early 1979 (see Figure 1.3-4) have been removed. The field office building and cafeteria/welfare building are the only remaining structures. Alchem Western, Inc. still has one large piece of equipment on site, as previously mentioned in Section 1.3.2. As discussed in Section 3.2.3, plant facility waste debris is buried both on and off the Gould property as part of the extensive landfill that occupies the study area (Section 3.2.2).

1.4.4 Planned Changes in Site

Planned changes in the study area include removal and/or containment of contaminated materials to provide an environment acceptable for public health and safety. The study area is zoned industrial by the City of Portland. There are no known plans to change this status. There are no known plans for construction on the Gould or ESCO properties.

1.4.5 Potential Pathways and Impacts of Contaminants from Site

Potential pathways for the spread of contamination include air, soil, surface water and ground water. Contaminated airborne particles might spread from exposed piles of battery casing fragments, matte and

soil. Precipitation runoff passing over contaminated materials could carry leachates along surface drainages and into existing bodies of surface water. Surface vegetation and aquatic organisms might absorb contaminants, which could later be passed on to various forms of animal life. Precipitation migrating downward through buried contaminated materials may transmit contaminants to the ground water, where they would migrate laterally and vertically within local aquifers.

The actual contaminants found during the study investigation, as well as their concentrations, direction, and speed of migration are discussed quantitatively in Section 4.0.

1.4.6 Previous Actions to Mitigate Problem

The contamination problem related to the secondary lead smelting facility has been recognized for some time. Records indicate that the Air Quality Control Division of the Portland Bureau of Health pointed out the potential for airborne lead emissions as early as 1966. DEQ documented that facility discharges into Doane Lake contained 9.5 and 10.3 parts per million (ppm) lead in 1973. As indicated in Table 1.3-1, numerous complaints and/or violations were recorded over the years. However, most of the available records indicate only the problem. Attempts to solve or reduce these problems remain largely unrecorded. Available information on actions taken to mitigate the contamination problem includes:

- ° The initiation of a respirator program for facility employees by Kirk & Sons in 1966.
- ° The curtailment of smelting operations in 1973 by NL Industries, in spite of rising lead prices.
- ° The trial shipment of waste acid to a hazardous waste management facility in Arlington, Oregon, in 1978 by NL Industries.
- ° Provisions initiated by Gould Inc. in January 1980 to neutralize the waste acid with ammonia and discharge into the Portland sanitary sewer system.

- ° The terminations of battery decasing operations in April 1981 and lead oxide production in May 1981 by Gould Inc.
- ° The closing of the facility in August 1981 by Gould Inc., and the disposal of most of the buildings and equipment in 1982.
- ° The mobilization of Alchem Western equipment and personnel to the plant site, as authorized by Gould, in an attempt to recover battery casing fragments and lead from the East Doane Lake remnant in January 1984. Equipment problems forced the abandonment of this project.
- ° Covering the piles of battery casing fragments along the East Doane Lake remnant pond with waterproofed canvas sheets to control dust, in April 1986.

In an effort to define the types, concentrations, and extent of contamination on the plant site, Gould Inc. retained Dames & Moore in 1982 to perform subsurface soil drilling and sampling, well installation, ground-water monitoring, chemical testing, and ambient air quality monitoring.

3.0 HAZARDOUS SUBSTANCES INVESTIGATION

3.1 INTRODUCTION

The following sections describe the source, type, location, and composition of the wastes identified during the Gould Remedial Investigation. The information presented is based on both historical records (agency files, aerial photographs and reports from previous investigations, etc.) and the results of the field investigation at the site. In addition, the characteristics and behavior of the identified waste components (including toxicity, bioaccumulation, metabolism, environmental transformation and transport behavior) are discussed.

The principal contaminant investigated during the Gould Remedial Investigation was lead. A limited number of samples were also analyzed for arsenic, zinc, chromium, cadmium, and sulfate. The primary sources of these contaminants were shredded battery casings, battery electrolyte (acid), and blast furnace matte resulting from the operations on the Gould site.

3.2 WASTE TYPES

The primary waste sources identified during the Gould Remedial Investigation were a secondary lead smelter and related processes operated from 1949 to 1980 on the Gould site. Hard rubber (ebonite) and plastic battery casing fragments, sulfuric acid, blast furnace matte and sweepings from zinc melting and alloying were the main wastes produced by these processes. Additional wastes were disposed on the investigation site by adjacent industries. The wastes produced by these adjacent industries included hydrated lime, acetylene residues, and shredded automobile interiors. Landfilling on and in the site vicinity also contributed to the wastes at the site. In addition, contamination released by the primary waste sources described above accumulated at other locations creating potential secondary waste sources. These potential secondary waste sources include accumulations in surface soils, subsurface soils, and sediments.

3.2.1 Site Process Waste Sources

This section describes the wastes produced from sources located on the Gould site. The secondary lead smelter and related operations are described and the wastes generated by these processes are identified.

3.2.1.1 Smelter Operations

Morris P. Kirk & Sons operated the secondary lead smelting facility from 1949 to 1971, when it was purchased by NL Industries. NL closed the smelting operations on July 30, 1973 and sold the plant to Gould Inc. in January 1979. Gould terminated lead refining in January 1980, and the entire facility was closed in August 1981. A chronological history of the site operations is presented in Table 1.3-1.

The processes operated on the Gould site are shown on the process flow diagram (Figure 3.2-1). As indicated on this figure, the waste streams resulting from the battery recycling smelter processes were: (1) battery (sulfuric) acid, (2) shredded hard rubber and plastic battery casings, (3) shredded plastic battery tops, and (4) blast furnace matte. A description of the battery casing recycle operation is presented below.

The battery tops were cut off and the untreated sulfuric acid was drained to a sump which flowed into the Doane Lake remnant adjacent to the Gould site. After October 1976, the acid was neutralized and discharged to the City of Portland sewer system. The casings, tops and electrode elements (groups) were placed in separate storage bins. The casings were shredded and eventually used as fill material on the Gould site and adjacent properties (Section 3.2.3). The tops were shredded and separated, with the lead materials going to the blast furnace and the plastic tops used as fill materials. The electrode elements were fed directly to the blast furnace. Flue dust from the blast furnace, the reverberatory furnace and the pot room were recycled to the blast furnace. Furnace slag from the blast furnace was separated into three layers as it cooled: slag, matte and speiss. Furnace slag from

the reverberatory furnace and the speiss and slag from the blast furnace were recycled back to the blast furnace. The only waste stream resulting from the blast furnace was the matte.

3.2.1.2 Other Site Operations

The other operations on the Gould site included lead oxide manufacturing, zinc alloying and copper wire stripping processes. The wastes produced by the zinc alloying process included sweepings and cleaning residues (Figure 3.2-1). The wastes produced by the copper wire stripping process included plastic insulation materials and recycled lead.

3.2.2 Other Potential Waste Sources

This section describes potential sources and waste types resulting from industries adjacent to the Gould site and landfilling operations. Possible secondary sources are also described.

3.2.2.1 Adjacent Industries

The industries located adjacent to the Gould site include American Steel Industries, Rhone-Poulenc Inc., ESCO Corporation, Schnitzer/Liquid Air Corporation, and Pennwalt Corporation (Figure 1.3-2). The major wastes identified from these adjacent industries included shredded automobile interiors from an unknown source on the Schnitzer/Liquid Air property, herbicides and other organics (phenols) and demolition debris from Rhone-Poulenc, steel scrap and zirconium casting sand from an ESCO steel mill outside of the study area, lime and alkaline acetylene waste from Liquid Air, and metallic wastes from Pennwalt.

3.2.2.2 Landfilling Operations

The materials used during the landfilling operations at the investigation site varied widely. Hydraulic fill dredged from the Willamette River and quarry rock were used as well as significant quantities of foundry sand, steel mill slag and construction debris such as concrete rubble, brick, wood, asphalt and natural soil. As described above, the fill materials also included industrial waste materials such as battery

casing fragments, blast furnace matte, shredded automobile interiors and alkaline acetylene waste.

Available aerial photographs taken since 1936, and topographic mapping as early as 1884, indicate that the study area now occupied by the Gould property and adjacent industries was formed by gradual and intermittent filling of a fairly large body of shallow water known as Doane Lake (Figure 3.2-2). Originally, a sand bar or mud bank was present between the Willamette River and Doane Lake. By 1936, however, all the study area properties, with the exception of ESCO and a portion of Rhone-Poulenc, had already been formed by filling the lake. These pre-1936 fills appear to have been primarily from hydraulic dredging of the Willamette River and from rock quarries.

Between the time air photos were taken in 1936 and 1948, there was relatively little landfiling activity. The Liquid Air facility was constructed sometime between 1940 and 1948 and the Pennwalt facility was built in 1941. Some grading was undoubtedly required prior to construction, but essentially no new landfill areas in Doane Lake were created by these additional industries.

By the time of the May 1957 air photos, Morris P. Kirk & Sons had operated the secondary lead smelter for about eight years. Battery casing fragments and other debris had been filled into Doane Lake and occupied most of the shoreline adjacent to the plant area. ESCO had begun to place foundry sand and slag into the lake at the corner of what was later to be Front Avenue and the northernmost corner of the NL property (Figure 3.2-2).

By the time the December 1963 air photos were taken, a large pile of battery casing debris was evident in Doane Lake along the northwest side of the plant area. Debris also extended into the lake along the entire plant area shoreline to the northeast. ESCO landfill had also expanded considerably and was within about 100 feet of the battery casing debris. In addition, Rhone-Poulenc had begun to place landfill in the area to the north of their plant.

At the end of October 1969, Doane Lake had been divided into two remnants (east and west) by the continued landfill activity of ESCO, Rhone-Poulenc, and Morris P. Kirk & Sons. Liquid Air and Gilmore Steel (later American Steel) appear to have placed minor quantities of fill along the lake shore adjacent to their respective properties, perhaps to raise the grade and stabilize shorelines.

Between the 1969 and 1972 air photos, considerable landfill was placed in a portion of the East Doane Lake remnant, which occupied the northwesterly half of the Liquid Air property. By August 1972, the West Doane Lake remnant continued to shrink in size as landfill placement continued by Rhone-Poulenc and ESCO. Aerial photographs dated August 3, 1972 also show fill placement on the Pennwalt property for the purpose of raising existing site grade (Figure 3.2-2).

By the time of the October 1979 air photos, the East and West Doane Lake remnants were essentially the same as they presently exist (Figure 1.3-4). A holding pond was present adjacent to the northwesterly end of the Liquid Air building, presumably for the purpose of storing lime byproduct from acetylene manufacturing. This pond has subsequently been filled. Landfill placement by Rhone-Poulenc and ESCO had ceased by this time. Gould had discontinued purchasing batteries, but a considerable inventory of stockpiled batteries were still on hand for processing. For this reason, battery casing debris continued for a time to be placed into the East Doane Lake remnant in the northerly portion of the Gould property. Some reduction in the size of the east remnant occurred along N.W. Front Street as a result of a sewer line project during early to mid-1979. Material excavated for the line was apparently placed into the east side of the East Doane Lake remnant.

3.2.2.3 Secondary Sources

The primary waste sources described above may have released other contaminants into soil and ground water. If these materials were sufficiently contaminated, they would become potential secondary sources of the contamination. These potential secondary sources included surface and subsurface soils on the Gould site and adjacent properties, and sediments in the Doane Lake remnants.

3.2.3 Disposal Locations

The disposal locations for the battery casing, blast furnace matte and other wastes were described above (Section 3.2.2.2). This section further discusses the disposal locations and includes a summary of the results of field investigations conducted to verify the historic locations identified for these wastes. Additional discussions of these field investigations are presented in other sections of this report (Sections 4.2 and 4.3).

3.2.3.1 Historic Disposal Locations

The various waste products from the Gould site operations were disposed in Doane Lake as close to the plant facility as possible. It has been reported that during the years of smelter operations (1949-1973), all battery casing fragments were used as fill material on the Rhone-Poulenc property, along the northwest corner of the plant site. This area was formerly owned by the railroad. Matte and other debris were used as fill material along the northeast portion of the plant site. It was reportedly not until after 1973 that any battery casing fragments were disposed on the plant site and these were reportedly placed over the previous matte waste deposits (Moore 1986a).

3.2.3.2 Results of Remedial Investigation

The historical battery casing disposal locations were verified by a test pit program and surface surveys. Ten test pits were dug off site on the Rhone-Poulenc and ESCO properties to verify the lateral extent of buried battery casings (Figure 3.2-3). The test pit depths ranged from 8.5 to 12.5 feet, usually to ground water. Geologic logs of the test pits were made by a Dames & Moore geologist and photographs of the test pit side wall were taken. The test pit logs are presented in Appendix D4.

Onsite surface surveys were conducted to verify the locations and approximate volume of surface battery casing piles on the Gould property. Four main areas of surface battery casing disposal were

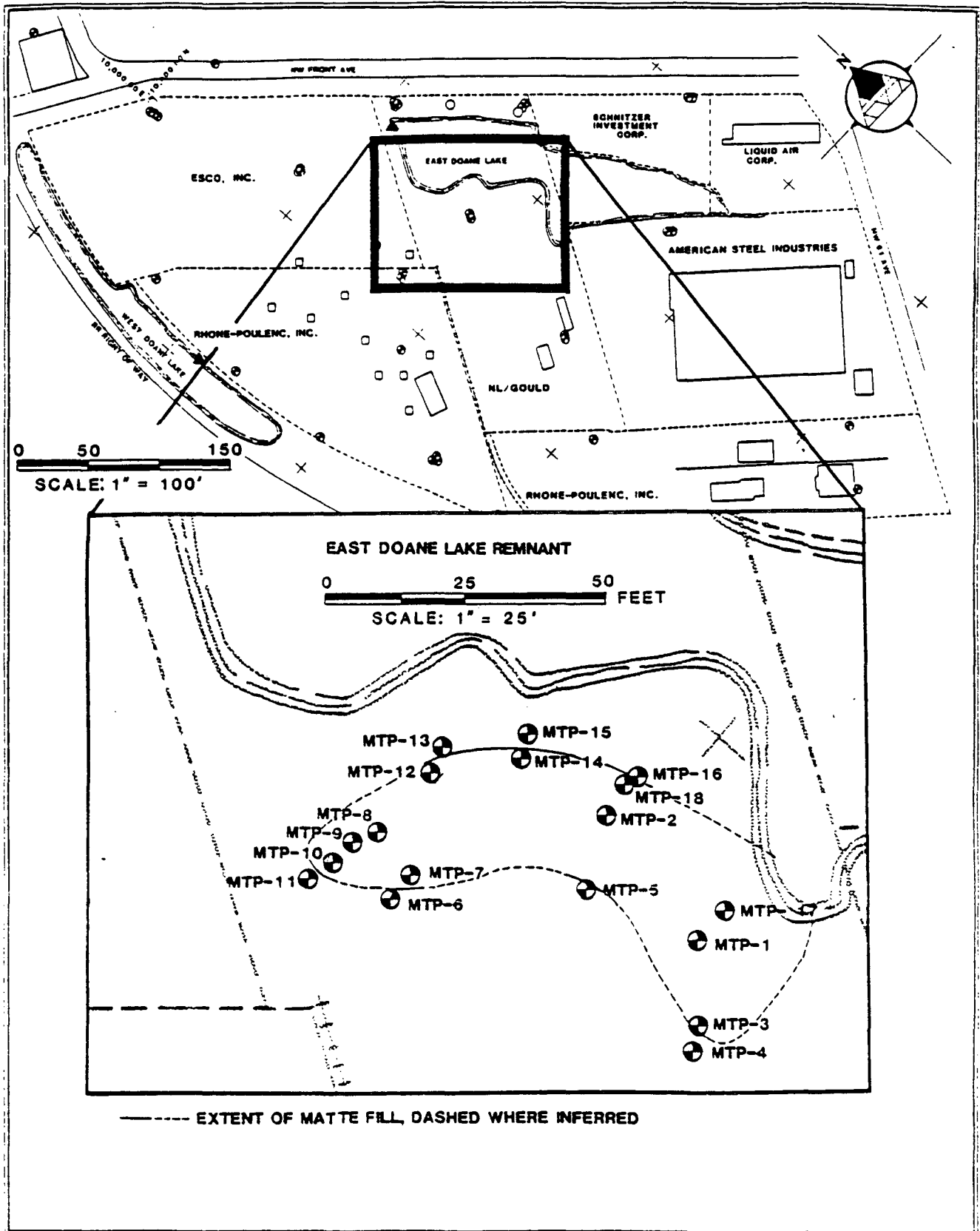
identified (Figure 3.2-3). As described below (Section 3.2.4.2), these locations were used for battery casing sample collection. Test pit results verified the reported locations of battery casing disposal along the northwest edge of the Gould property. The surface surveys and battery casing sampling confirm the reported disposal locations along the northeastern edge of the property.

Additional battery casings have been used as fill material for a road and part of the parking lot on the Gould property along the property boundary between the eastern edge of the Gould property and American Steel property (Figure 3.2-3). A maximum depth of 18 inches was reported, so the total volume of material is small compared to the major disposal areas described above, within the limitations of the overall estimate of materials on site.

The reported matte disposal locations were verified by a test pit program. Seventeen test pits were made on the Gould property near the edge of the East Doane Lake remnant (Figure 3.2-4). The test pit depths ranged from 0.5 to 3.0 feet, usually to ground water. Due to the hardness of the matte material, some test pits were not advanced to ground water. Geologic logs of the test pits were made by a Dames & Moore geologist and photographs of test pits were taken. The test pit logs are presented in Appendix D4.

The test pit results verified the matte disposal locations along the northeastern edge of the Gould property. Due to the shallow depth to ground water (approximately 3 feet) and the hardness of the matte material, the vertical extent of the matte could not be determined in the test pits.

The disposal locations of the wastes from the industries located adjacent to the Gould property were verified by surface surveys (Figure 3.2-3). The alkaline acetylene wastes from Liquid Air and the shredded autobodies from the American Steel facility were found along the edge of these properties and the East Doane Lake remnant.



NL IND, INC./GOULD, INC.
REMEDIAL INVESTIGATION

MATTE TEST PIT LOCATIONS

FIG. 3.2-4

DAMES & MOORE

11831-034

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Secondary sources were identified during the field investigations at the site. Surface soils with the highest lead concentrations were located on the Gould property and on the adjacent Rhone-Poulenc property. These locations correspond with known smelter operations and disposal locations. The highest lead concentrations in subsurface soils samples were detected at Well W-7S in the vicinity of the battery casings disposal area (Section 4.2.4). The highest lead concentrations in the sediments were found in the East Doane Lake remnant, with lower concentrations detected in the west remnant (Section 4.2.5). The high lead concentrations in these materials make these contaminated surface soils, subsurface soils, and sediments potential secondary sources.

3.2.4 Waste Quantities, Components and Composition

This section describes the quantities, components and composition of the wastes identified at the site. These wastes include both primary wastes, such as battery casing and matte materials, and secondary wastes, such as contaminated surface soils, subsurface soils and sediments.

The quantities of waste produced at the Gould site and the quantities of waste disposed off site and on site were estimated using the following information sources: (1) personal communications with site personnel (Gene Moore); (2) aerial photographs and topographic maps; and (3) the field investigation results. Information obtained from communications with Mr. Moore resulted in generating approximate production rates and disposal locations for battery casings and matte. The aerial photographs, topographic maps and information from communications with Mr. Moore were used to develop a fill thickness contour map (Figure 4.2-26). This map was used to estimate the volumes of battery casing materials in areas where the lateral extent of the waste had been established. The field investigations results were used to evaluate the lateral extent of the battery casing and matte materials and to verify the fill thickness map estimations. The components and composition of the wastes were assessed by physical inspection and chemical analysis.

3.2.4.1 Waste Quantities and Components

The lead smelter on the Gould property operated between 1949 and 1973. During this period, a daily production of approximately 35 to 40 tons of lead has been reported. Approximately 75 percent of this daily lead production resulted from lead-acid batteries. The furnace operated on a 24-hour schedule with 10 days on and 10 days off to allow time for cleanout.

The average recycled automobile battery weighed about 39 pounds. It contained 24 pounds of lead and lead oxide, one-half gallon (5.4 pounds) of sulfuric acid, and approximately 9.6 pounds of hard rubber and plastic casing. Approximately 3,000 batteries were processed every day the furnace was in operation. Since the furnace operated 50 percent of the time, an overall average of 1,500 batteries were assumed to be processed daily during the life of the smelter. This results in an estimate of approximately 274,000 gallons (1,480 tons) of acid and 2,600 tons of battery casings to be disposed of yearly.

In addition to acid and battery casings, a third waste product called matte was produced by the smelting operation. When the furnace was operating, impurities were drawn off four times an hour or 96 times in a 24-hour period. Each withdrawal amounted to about 85 pounds of which 60 percent or 51 pounds was matte, 32 pounds was slag, and 2 pounds was speiss. The slag and speiss were recycled back to the furnace while the matte was used as fill material as discussed above. Total daily matte production was about 5,400 pounds, but since the furnace operated only half the time, the overall production of matte averaged about 2,700 pounds per day. This results in an estimate of approximately 493 tons of matte per year that had to be disposed of over a 24-year period. Estimated daily, yearly, and total waste productions are presented below (Table 3.2-1).

All of the battery casing fragments produced during this period (1949-1973) were reportedly disposed off site on the Rhone-Poulenc property (Figure 3.2-3). The estimated total production of almost 12,000 tons of matte was reportedly used as fill only on the Gould site, just to the northeast of the facility (Figure 3.2-2).

TABLE 3.2-1

LEAD-ACID BATTERY RECYCLING AND SECONDARY LEAD SMELTING
WASTE PRODUCTS PRODUCTION ESTIMATES
GOULD FACILITY 1949 to 1973¹

Waste	Average Production		
	Daily	Yearly	Total
Battery Casing Fragments	7.2 tons	2,640 tons	63,000 tons
Acid (H ₂ SO ₄)	750 gal. 4.1 tons	274,000 gal. 1,480 tons	6,570,000 gal. 35,500 tons
Matte	1.4 tons	500 tons	11,800 tons

¹ The smelting furnace operated from 1949 (assume mid-1949) until July 1973. After the furnace shut down, waste production figures are less precise and are not included in this table (see Section 1.0).

Accurate production figures for battery casing fragments after 1973 are not available. Reportedly, the work crew operated on a 5-day week with many batteries drained of acid and shipped to Los Angeles or directly overseas for recycling. It appears that relatively small amounts of battery casing fragments were produced after 1973 as compared with the quantities produced prior to that date. Based on the limited estimated production figures, battery casing fragments produced after 1973 probably did not exceed about 12,000 tons. These post-1973 battery casings were reportedly disposed on top of the matte along the north-eastern side of the Gould property (Figure 3.2-3).

The quantity of battery casing materials disposed off site on the Rhone-Poulenc property was calculated using the test pit results and the fill thickness contour map. A three-dimensional picture of the waste volume was constructed by assuming that wherever battery casings were found during the test pit program, the casing material extended vertically to the bottom of the fill. This assumption is supported by test pit and soil boring results indicating that where battery casings are present, battery casing thickness is approximately equal to the estimated fill thickness. Subsurface cross sections were made through

the off-site battery casing area shown on Figure 3.2-3 at 50-foot intervals. The volume of each of these 50-foot wide cross sectional pieces was calculated by multiplying the maximum fill depth for that piece (obtained from the fill thickness map) times the length of the piece (obtained from the lateral extent information provided by the test pits) times the 50-foot width.

Using this calculation approach, an estimate of approximately 26,700 cubic yards of battery casing material is located on the Rhone-Poulenc property. The 63,000 tons of battery casings produced between 1949 to 1973, reportedly disposed off site on the Rhone-Poulenc property, have an approximate volume of 66,700 cubic yards (assuming a density of 70 pounds/cubic foot). This results in a difference of approximately 40,000 cubic yards between the volume of battery casings reportedly produced and disposed on the Rhone-Poulenc property between 1949 and 1973 and the apparent volume of casings actually located on the Rhone-Poulenc property. A probable explanation for this discrepancy is presented below.

The amount of fill material placed into the East Doane Lake remnant along the northeastern boundry of the Gould property is estimated to be approximately 75,000 cubic yards. This estimate is based on information obtained from communications with Gene Moore, aerial photographs, the fill thickness contour map, and surveys of surface battery casing piles in the area. The volume was calculated by multiplying the approximate lateral extent of the fill (220 feet X 370 feet) times the average fill thickness for the area (25 feet). Reportedly, 6,000 cubic yards of this fill is matte (assuming a density of 150 pounds/cubic foot) and 13,000 cubic yards is the post-1973 battery casings. Survey results of the surface battery casing piles indicates that these piles contain approximately 1,700 cubic yards. This results in approximately 54,000 cubic yards of fill unaccounted for.

In addition to the battery casings and matte, other materials, including trash, wood, construction debris, and soil, were used as partial fill along the northeastern boundary of the Gould property. The amount of this other material used as fill in the East Doane Lake

remnant is not known but it is highly unlikely that this material could account for all of the 54,000 cubic yards of unaccounted fill. Therefore, it is probable that the 40,000 cubic yards of pre-1973 battery casings that were not found off site on the Rhone-Poulenc property were actually used as fill on site in the East Doane Lake remnant. This conclusion is well-supported by aerial photos from the 1950's and 1960's. These photos indicate that the material used as fill on the Rhone-Poulenc property (battery casings) was quite similar in appearance to the material being used as fill in the East Doane Lake remnant.

Table 3.2-1a summarizes the locations and quantities of battery casings and matte.

TABLE 3.2-1a

BATTERY CASINGS AND MATTE QUANTITIES AND LOCATIONS

	BATTERY CASINGS		MATTE
Gould Property (1949-1973)	40,000 cu yds	37,800 tons	12,000 tons
(post-1973)	12,700 cu yds	12,000 tons	
Rhone-Poulenc Property	<u>26,700</u> cu yds	<u>25,200</u> tons	
Totals	79,400 cu yds	75,000 tons	<u>12,000</u> tons

The quantities of surface soil, subsurface soil, and sediment considered to be secondary sources were estimated by using total lead and EP Toxicity data. A quantitative relationship between EP leachate lead and total soil lead concentrations in the study area was calculated from the limited number of data points and the variable nature of the materials. After comparing the total soil lead concentrations to the corresponding EP Toxicity data (Section 4.2), an assumed total soil lead concentration of 3,000 mg/kg was estimated to be the limit below which the EP Toxicity leachate concentration would be below 5.0 mg/l for lead. Samples with total lead concentrations above 3,000 mg/kg were used to indicate secondary source areas.

The 3,000 mg/kg threshold for determining secondary sources was estimated as follows. The sample with the highest total lead concentration that did not have a corresponding EP Toxicity leachate lead concentration above 5.0 mg/l was found. The highest total lead concentration found in the samples analyzed that met this criteria was 1,500 mg/kg, measured in sediment sample SD-10 and in surface soil sample SS-06 (Appendix C, Table C-3 and C-5). Both of these samples had EP Toxicity leachate lead concentrations of 0.2 mg/l, well below the maximum of 5.0 mg/l. To account for the variability of samples, the total lead concentration of 1,500 mg/kg was doubled and the resulting 3,000 mg/kg concentration was used as the secondary source threshold. The secondary source quantity calculations are described below.

The highest surface soil total lead concentrations were detected in samples collected on the Gould property and on adjacent Rhone-Poulenc property. Figure 3.2-5 shows the areas of surface soil that were identified as secondary source areas using the above total lead criteria and the following assumptions: (1) the depth of the secondary source material was assumed to be 1-foot; and (2) the horizontal extent of the material was assumed to be 50-feet in any direction from the sample locations with total lead concentration above 3,000 mg/kg. Using these assumptions, the quantity of surface soil on the Gould property considered a secondary source is approximately 2,400 cu yds. The quantity on Rhone-Poulenc property is approximately 970 cu yds.

The highest subsurface soil total lead concentrations were detected in samples collected from the W-7S boring, in the battery casing material. The total lead results for samples collected 2-feet below the bottom of the battery casing material in W-7S indicate that the total lead concentration decreases to below 1,000 mg/kg (Section 4.2). Based on this result, we assume that the 3,000 mg/kg isopleth for lead in subsurface soil would be reached approximately 1 foot below the casings and matte. Therefore, the subsurface soils considered secondary sources are the soils within one foot of the bottom and sides of the battery casing material buried on the Rhone-Poulenc and Gould property. The horizontal extent of these two battery casing disposal areas is shown on Figure 3.2-3. The secondary source subsurface soils consist of the following:

1. One foot of soil below the entire area of the battery casing/
matte excavations. This would amount to 4,300 cu yds from the
area on Rhone-Poulenc property and 5,000 cu yds from the area
on the Gould property; and,
2. One foot of soil from the sides of the excavations. Assuming
average excavation depths of 20-feet on the Rhone-Poulenc pro-
perty and 25-feet on the Gould property, and an excavation
side-slope ratio of 2:1, this would amount to approximately
2,170 cu yds from the Rhone-Poulenc property and 2,180 cu yds
from the Gould property.

The highest sediment total lead concentrations were detected in the
East Doane Lake remnant. The areas considered secondary sources are
shown on Figure 3.2-5. Based on an assumed depth of 1-foot, the quan-
tity of material would be approximately 5,500 cu yds.

The total quantity of soil considered secondary source material is
summarized below:

<u>TYPE AND LOCATION</u>		<u>QUANTITY (cu yds)</u>
<u>Surface Soil</u>		
Gould property	2,400	
Rhone-Poulenc property	<u>970</u>	
Surface Soil Subtotal		3,370
<u>Subsurface Soil</u>		
Gould property	5,000	
Bottom Sides	<u>2,180</u>	
Sub-total		7,180
Rhone-Poulenc property	4,300	
Bottom Sides	<u>2,170</u>	
Sub-total		6,470
Subsurface Soil Subtotal		13,650
<u>Sediment</u>		
East Doane Lake Remnant	<u>5,500</u>	
Sediment Subtotal		5,500
Secondary Source Total		22,520

3.2.4.2 Waste Composition

The battery casings consist of hard rubber (ebonite) and plastic casings, metallic lead and lead oxides. Battery casing samples were collected at four sample locations, BC-1 through BC-4 (Figure 3.2-3). The samples were collected from surface piles identified during site surveys. Three samples were collected at each location: 1) at the surface; 2) at a depth of 5 feet below the surface; and, 3) at the approximate depth of the original ground surface (beneath the pile). The samples were non-homogeneous and required preparation before analysis. The battery casing samples were prepared by hand-picking plastic pieces larger than 2 inches and lead and non-lead metal pieces larger than 1/4-inch from the sample to be prepared. The weight of rock/slag was measured, recombined with the sample and then the sample was crushed/ground to less than 9-millimeter particle size and homogenized. An aliquot of this homogenized sample was analysed. Table 3.2-2 presents the results of the sample preparation and Table 3.2-3 presents the results of the prepared sample analyses.

The results for total lead indicate that the lead concentrations (mostly lead oxide) in the prepared battery casing samples ranged from 7,600 mg/kg (0.76 percent) to 190,000 mg/kg (19 percent). All of the samples had EP Toxicity results for lead above the regulatory limit (EP Toxicity limit = 5.0 mg/l). These values ranged from 21 mg/l to 220 mg/l. The data indicate that there was no apparent correlation between total lead concentration and EP Toxicity leachate lead concentration for these samples. The EP Toxicity results for arsenic, chromium, and cadmium indicate that these contaminants were not detected in the EP leachates.

TABLE 5.2-2

BATTERY CASING SAMPLE COMPOSITION BY WEIGHT¹

Sample ²	Depth ³	Hard Rubber ⁴	Plastic ¹	Metallic Lead ¹	Lead Oxide ⁵	Non-lead Metal ¹	Rock/Slag	Total Sample Weight	Moisture
BC-1	Surface	2021.01	2181.00	1.50	601.15	44.90	7397.0	12358	111.44
	5 Feet	3950.46	3030.00	50.20	902.75	0.00	1595.0	9660	131.60
	Ground	6471.97	3061.00	122.00	1232.76	0	0.0	11397	509.27
BC-2	Surface	8713.34	2154.00	207.00	839.81	0	1497.0	14005	593.84
	5 Feet	5245.99	2381.00	195.00	1239.15	0	399.0	9923	462.86
	Ground	6153.39	1615.00	184.00	1211.60	0	1955.0	11651	532.01
BC-3	Surface	4408.47	1841.00	182.00	1115.01	0	345.0	8136	244.52
	5 Feet	3479.62	1642.00	217.00	678.78	0	84.0	6377	275.60
	Ground	6107.06	2721.00	138.00	1269.07	0	89.0	10912	587.87
BC-4**	Surface	9834.31	0.00	186.00	149.76	0	0.0	10830	659.93
	5 Feet	10314.58	0.00	616.00	363.04	134	0.0	11792	364.39
	Ground	8902.87	0.00	85.00	218.92	0	0.0	9697	490.21

¹Plastic larger than 2-inches and lead metal and non-lead metal larger than 1/4-inch removed in sample preparation and were not included in the analysis.

²Ground sample collected at a depth approximately equal to the projected ground surface.

³These casing samples were processed by the Alchem Western separation machine.

⁴Calculated from the difference of the total sample weight and the sum of the other components.

⁵Calculated from the analysis result for the prepared samples.

TABLE 3.2-3

PREPARED BATTERY CASING SAMPLE ANALYSIS RESULTS

SAMPLE NUMBER/ LOCATION	DEPTH ¹	TOTAL LEAD (mg/kg)	EP LEAD (mg/l)	EP ARSENIC (mg/l)	EP CHROMIUM (mg/l)	EP CADMIUM (mg/l)
BC-1	Surface	60,000	160	U0.2	U0.1	U0.05
	5 feet	140,000	21	U0.2	U0.1	U0.05
	Ground	16,000	220	U0.2	U0.1	0.06
BC-2	Surface	7,600	200	U0.2	U0.1	U0.05
	5 feet	180,000	140	U0.2	U0.1	U0.05
	Ground	130,000	100	U0.2	U0.1	U0.05
BC-3	Surface	190,000	190	U0.2	U0.1	U0.05
	5 feet	160,000	220	U0.2	U0.1	U0.05
	Ground	170,000	120	U0.2	U0.1	U0.05
BC-4	Surface	15,000	200	U0.2	U0.1	U0.05
	5 feet	34,000	130	U0.2	U0.1	U0.05
	Ground	24,000	81	U0.2	U0.1	U0.05

¹Ground sample collected at a depth approximately equal to the projected ground surface.

Using the results of the prepared samples, total percentages of the various components of the battery casing samples were calculated. These percentages are presented in Table 3.2-4. The results indicate that battery casing mixtures have a total lead content (metallic lead and lead oxide) of between 3 to 15 percent lead. Also, the results for Sample BC-4, which was collected from a pile of battery casings that had been separated in a pilot-scale test, indicate that the separation was efficient. Hard rubber content increased, plastic was removed and lead was, in general, reduced.

The matte materials consist of metallic sulfide chunks primarily containing iron and lead. Matt samples were collected from four of the matte test pit locations: MTP-1, MTP-5, MTP-7 and MTP-8 (Figure 3.2-4). The samples were collected at depths ranging from 0.5 feet to 3.0 feet

TABLE 3.2-4

Composition of Battery Casing Samples Collected on Gould Property

Percentages of Mixture							
Sample #	Hard Rubber	Plastic	Metallic Lead	Lead Oxides	Non-lead Metal	Rock/Slag	Moisture
1	16.35	17.65	0.01	4.86	0.36	59.86	0.90
2	40.89	31.37	0.52	9.35	0.00	16.51	1.36
3	56.79	26.86	1.07	10.82	0.00	0.00	4.47
4	62.22	15.38	1.48	6.00	0.00	10.69	4.24
5	52.87	23.99	1.97	12.49	0.00	4.02	4.66
6	52.81	13.86	1.58	10.40	0.00	16.78	4.57
7	54.18	22.63	2.24	13.70	0.00	4.24	3.01
8	54.57	25.75	3.40	10.64	0.00	1.32	4.32
9	55.97	24.94	1.26	11.63	0.00	0.82	5.39
Averages:	49.63	22.49	1.50	9.99	0.04	12.69	3.66

below ground surface. The samples were prepared by crushing/grinding the metallic chunks to less than 9-mm particle size and then homogenizing sample before analysis. The results for the analyses of the matte samples are presented in Table 3.2-5.

TABLE 3.2-5
MATTE ANALYSIS RESULTS

SAMPLE NUMBER	SAMPLE LOCATION	DEPTH (ft)	pH	TOTAL LEAD (mg/kg)	EP LEAD (mg/l)	EP ARSENIC (mg/l)	EP CHROMIUM (mg/l)	EP CADMIUM (mg/l)
MT-1	MT-1	1.0	5.2	92,000	12	U0.01	U0.1	0.04
MT-2	MT-1	2.5	5.4	97,000	59	U0.01	U0.1	0.06
MT-3	MT-5	0.5	5.3	110,000	27	U0.01	U0.1	0.34
MT-4	MT-7	0.5	5.2	74,000	7.2	0.02	U0.1	0.19
MT-5	MT-7	3.0	5.7	64,000	6	0.03	U0.1	0.04
MT-6	MT-8	2.0	5.5	74,000	12	0.02	U0.1	0.01

The results for total lead indicate that lead concentrations in the matte samples ranged from 6.4 percent to 11 percent. All of the samples had EP Toxicity results for lead above the regulatory limit of 5.0 mg/l. These values ranged from 6 mg/l to 59 mg/l. As with the battery casing EP Toxicity results, the data indicate that there was no apparent correlation between total lead concentration and EP Toxicity leachate lead concentration for these samples. Low concentrations of arsenic and cadmium were detected in the EP Toxicity leachates. These concentrations are within the regulatory limits (5.0 mg/l and 1.0 mg/l, respectively).

The EP Toxicity results discussed above for the battery casing and matte samples provide a preliminary assessment of the potential for lead and arsenic to leach from these two primary source materials. Additional leach potential testing was conducted under varying pH conditions. These tests are discussed in Sections 7.3 and 7.4.

3.2.5 Waste Containment

This section describes possible waste containment at the site. The types of containment discussed are geochemical, stratigraphic, hydraulic and anthropogenic.

3.2.5.1 Geochemical

The primary source of contaminant containment arises from geochemical reactions between the mobilized contaminants and the soils at the site. As described below (Section 3.3.5) and elsewhere in this report (Sections 4.2 and 4.4), lead and other metals undergo chemical reactions between the dissolved contaminants and the soils resulting in the metals being removed from solution, thus, reducing the mobility of the contaminants. If the soils become saturated, and if pH is lowered through some mechanism, the metals may be released and become mobile again. This "ionic saturation" is an important release mechanism, especially for secondary sources. Once released however, the metals may be removed from solution by unsaturated soils. This continuing process determines the rate at which the metals migrate, if at all.

3.2.5.2 Stratigraphic

The stratigraphic influence on contaminant containment is a slight to moderate difference in permeability between the upper fill layer and the alluvium soils below the fill. This difference results in a larger component of horizontal, as opposed to vertical, ground water flow but the difference is not large enough to completely prevent downward migration of the contaminants (Section 4.4).

3.2.5.3 Hydraulic

Hydraulic containment is primarily due to the decreased downward ground-water flow caused by the permeability differences discussed above. Additionally, gradient leveling may occur during high river stages in the Willamette River, resulting in enhanced containment.

3.2.5.4 Anthropogenic

There are no anthropogenic containment systems at the site.

3.3 WASTE COMPONENT CHARACTERISTICS AND BEHAVIOR

The following sections discuss waste component characteristics and behavior. The waste components discussed are lead, arsenic, zinc, cadmium and chromium. The characteristics discussed include toxicity, bioaccumulation, metabolism, environmental transformation and transport behavior.

3.3.1 Toxicity, Bioaccumulation and Metabolism

Toxicity testing was not conducted during the investigation. A discussion of the toxicity and health effects of the contaminants is presented in Section 8.2. Testing to evaluate whether the wastes identified at the site are considered hazardous in relation to regulatory standards was conducted, and is discussed in Section 3.2.4. The results indicate that the battery casings, matte samples, and some soil samples analyzed exceed the EP Toxicity lead concentration limit for lead (5.0 mg/l).

Bioaccumulation testing was not conducted during the investigation. A discussion of bioaccumulation is presented in Section 8.1.2.3.

Metabolism testing was not conducted during the investigation. A discussion of the metabolism of the contaminants is presented in Section 8.0.

3.3.2 Environmental Transformation

Environmental transformation testing was not conducted. A brief discussion of possibly relevant information is presented here.

Biomethylation is an environmental transformation pathway for metals. Bacteria in the soil can use metals in their anaerobic metabolic process and produce chemical forms of the metal that have higher mobilities than the original form. The remobilization of metals by

biomethylation is not usually important for cadmium, chromium or zinc, but is more important for lead and arsenic. Lead can be transformed to methylated compounds such as tetramethyl lead and arsenic can be transformed to methylated compounds which can also lead to arsines. These compounds are more mobile and volatile than the initial dissolved form of the metals. Although this transformation is possible, the effect on lead mobility at the site is probably limited due to the lack of extensive anaerobic conditions.

3.3.3 Transport Behavior

Transport behavior testing was not conducted. The transport behavior of the contaminants is briefly discussed hereto and in the understanding of the data generated during the remedial investigation. Emphasis is placed on the physical and chemical interactions that affect the mobility of the contaminants.

3.3.3.1 Air

In general, the contaminants enter the air via particulate transport. Volatilization is not an important process for contaminants since they are non-volatile metals. Once in the air, the behavior of the contaminants is probably dependent only on physical influences such as wind speed and direction, temperature and precipitation. Volatile forms of lead and arsenic, if present, may be affected by photooxidation or other types of chemical oxidation in the air but in general, these chemical processes are of little importance with regard to the transport behavior of the contaminants in air.

3.3.3.2 Soil

In general, contaminant transport behavior in the soil depends upon the transport behavior of the contaminants in the ground water traveling through the soil. Depending upon the porosity and permeability of the soil material, particulate transport may be important.

3.3.3.3 Water

The transport behavior of the contaminants in water varies from one contaminant to another. In general, the contaminants are more mobile in water with lower pH. Sorption onto hydrous iron and magnesium oxides, clays and organic material is an important mechanism for containment of the contaminants, especially lead. Photolysis is not an important process except for lead, where the form of lead can be changed by photochemical reactions in surface waters.

The mobility of lead in the soil/water at the site is probably most strongly influenced by the chemical reactions between the dissolved lead and constituents in the water and soil. The pH is apparently the dominant controlling factor in lead mobility. Neutral to high pH conditions tend to result in low dissolved lead concentrations and low pH conditions result in higher dissolved lead concentrations. The pH effect is a result of the changing chemical equilibria that occur at different pH levels. At low pH, dissolved lead remains in solution and lead that is associated with particulate matter or precipitates is dissolved into solution. As the pH rises, the reverse occurs; dissolved lead precipitates out of solution and/or sorbs onto particulates. In general, this is true for the other contaminants as well. At very high pH (>11) soluble hydroxides increase the dissolved lead concentrations. The role of these processes in the mobility and extent of contamination at the site is discussed further in Section 4.0.

4.0 HYDROGEOLOGY AND HYDROGEOLOGY INVESTIGATIONS

4.1 SCOPE OF INVESTIGATIONS

The geology and hydrogeology of the site and adjacent areas were assessed by performing the following activities:

- ° Photogeologic mapping;
- ° Drilling and sampling of four boreholes and installation of 17 monitoring wells;
- ° Collection of 59 surface soil samples;
- ° Physical testing of the 59 samples;
- ° Ground-water and surface water sampling; and
- ° In-situ and laboratory testing of permeability.

The following sections discuss the findings and interpretations of the field and laboratory results.

4.2 GEOLOGY

4.2.1 Regional Geology

The Gould site is located on the left bank floodplain of the Willamette River, approximately 7 miles upstream from the confluence of the Willamette River and the Columbia River (Figures 1.3-1 and 4.2-1). The floodplain of the Willamette River occupies the lowest portions of the Willamette Valley, which is a broad downwarp between the Cascade and Coast Ranges of northwest Oregon and southwest Washington. The site is underlain by a few to several tens of feet of alluvial deposits, which in turn overlie the lava flows of the Columbia River Basalt. The site is situated on the northeast flank of the Portland Hills anticline, where the anticline dips beneath the young sediments that fill the Portland Basin (Figure 4.2-1).

The site area is underlain by a variety of volcanic and sedimentary rocks. From oldest to youngest these include the Scappoose Formation, the Columbia River Basalt, the Troutdale Formation, glaciofluvial flood deposits, and Holocene alluvium (Trimble 1963).

The Scappoose Formation consists of tuffaceous sandstones, siltstones and mudstones with local occurrences of coal and volcanic ash. Regionally, the Scappoose varies from a few feet in thickness to nearly 800 feet (Trimble 1963). It crops out several miles northwest of the site near the town of Scappoose. Near the Gould site, it lies at a depth of about 500 to 700 feet below ground surface (Brown 1963).

The Columbia River Basalt overlies the Scappoose Formation. In the Portland area, the Columbia River Basalt consists of 12 to 14 flows of hard basalt. The flows, which date from the Miocene age, are jointed and usually have rubbly or vesicular tops which contain most of the ground water. Often they are separated by a few inches or feet of sedimentary deposits (siltstone to sandstone). Some of the flows are weathered to a depth of a few feet. The basalt is estimated to be in excess of 500 feet thick beneath the Gould site (Trimble 1963). The basalt underlies the anticlinal Portland Hills, immediately west and

south of the site, and crops out in many areas along the flanks of the hills.

In the Portland area, the basalt is overlain by the Troutdale Formation. It consists of sandstone and conglomerate of Pliocene age. Most of the Troutdale Formation in the site area has been removed by erosion; only a few thin remnants are known along the Portland Hills (Trimble 1963, Treasher 1942). Local remnants of the Troutdale Formation may underlie the alluvium in the Gould site area, but none were encountered during drilling and none have been reported in nearby wells.

Throughout most of the area, elevations below about 350 feet are mantled with sand, silt and gravel of late-Pleistocene age. These sediments were transported to the Portland area and deposited as a large delta by catastrophic floods of glacial meltwater that coursed down the Columbia River about 10,000 to 13,000 years ago (Trimble 1963). The glacio-fluvial flood deposits have largely been removed from the site area by erosion.

Alluvium deposited by the Willamette River underlies the floodplain. The alluvium consists of channel and bar sands and silty sands, levee silt and sandy silt, and various overbank lacustrine silts and clays. Prior to development, most of the site was occupied by Doane Lake, which comprised part of an abandoned prehistoric channel of the Willamette River. Figure 4.2-2 shows the location of the lake and abandoned channel during the late-1800's.

The major structural features of the site area are the Portland Hills anticline and the Portland Basin (Figure 4.2-1). The Portland Hills anticline is a 30-mile-long, northwest-striking anticline that extends from Oregon City to Scappoose, Oregon. It is a broad, relatively gentle fold, except along its eastern flank. The eastern flank of the anticline dips 15 to 30 degrees into the Portland Basin.

The Portland Basin lies east of the site. This basin is one of many which in aggregate form the Willamette lowland which extends from

Eugene, Oregon to Chehalis, Washington. The Portland Basin extends south to the Oregon City area and east to the foothills of the Cascades. The top of the Columbia River Basalt is at about 1,500 feet below sea level in the deepest part of the basin (Figure 4.2-1).

4.2.2 Site Geology

The site is located on man-made fills which were placed on the left bank floodplain of the Willamette River, about 7 miles downstream from the city center of Portland (Figure 1.3-1). These fills overlie alluvial deposits of Holocene age, which in turn overlie bedrock Columbia River Basalt (Figure 4.2-1). Geologic cross sections of the site are shown on Plates 4A, 4B and 4C. The cross section locations are shown on Figure 4.2-3.

4.2.2.1 Fill

Several different fill layers were placed at the site, beginning in the 1930s and 1940s and continuing up to the early 1980s (see Sections 1.3 and 3.2.2.2; Figure 3.2-2). The fills consist of a diversity of materials such as metal slag, scrap metal, demolition debris, silty hydraulic dredge spoils, spoils from the nearby rock quarry, shredded automobile interiors, shredded battery casings, matte, and carbide sludge, as discussed in Sections 1.3.2. and 3.2.2.2. Variations in fill thickness are shown on Plates 4A through 4C, and on the Fill Thickness Map, Figure 4.2-4. The fill thickness varies from about 1 foot to over 32 feet in the vicinity of well W-12D.

The surface of the site is covered with a variety of materials. For example, the western portion of the site is covered with a layer of clay. The wrecking yard adjacent to Rhone-Poulenc is covered by piles of debris and a silty, clayey layer of rubble. The southern two-thirds of the Gould property is overlain with asphalt and concrete. Piles of battery casing fragments are located immediately south of the East Doane Lake remnant. The western end of the adjacent Schnitzer property is covered with piles of rubble and one pile of shredded automobile interiors. The distribution of the surface materials is shown in Figure 1.3-3.

As indicated above, the source of the site fills is diverse. These soils exhibit corresponding dissimilar physical properties, as summarized on Table 4.2-1. Individual sample descriptions are based on the laboratory results and the Unified Soil Classification System (Appendix D5). The results of the physical properties tests are also included in Appendix D5.

4.2.2.2 Holocene Alluvium

Prior to receiving fill emplacement of the materials, the site was covered largely by Doane Lake which occupied a shallow, abandoned channel of the Willamette River (Figure 4.2-2). The alluvium beneath Doane Lake consists of a complex mixture of river channel sands, over-the-bank silts and sandy silts, and fluvio-lacustrine silt, clayey silt and silty clay. Isolated local lenses and stringers of volcanic ash, mudflow and sandy gravel are usually present in the alluvium, as are lenses of organic silt, peat and woody detritus (flotsam). The alluvium thickness varies from of 38 feet in well RPW-3D to 83 feet in well W-16D. Assuming that the dip of the basalt continues uniformly to the north (as shown on Figure 4.2-5), the alluvium is estimated to be about 93 feet thick in the vicinity of well W-10D.

Beneath the Gould site the alluvium consists primarily of sand, silt, and clay. Relatively continuous lenses of fairly clean sand are present, as are fairly continuous layers of clayey silt or clay. Lithologic variations within the alluvium beneath the site are shown in Plates 4A through 4C.

The physical properties of the alluvial materials were determined by laboratory tests and are summarized in Table 4.2-2. The results of the physical properties tests are included in Appendix D5. The individual sample descriptions are based on the laboratory results and the Unified Soil Classification System (Appendix D5).

TABLE 4.2-1

PHYSICAL PROPERTIES OF FILL AND SURFACE SOILS

Well or Boring	Sample No.	Depth (feet)	Plastic Limit	Liquid Limit	Plasticity Index	Water Content % (g/g)	Dry Density (g/cm ³)	Vertical ¹ Permeability (cm/s) ²	Soil Type ³
<u>Boring</u>									
B-6	13-6-16.5-D	16.5	N.P.	N.P.	N.P.	29.71	1.46	1.4 E-4	
<u>Wells</u>									
W-16-S	W-16-S-3	5	---	---	---	98.58	0.78	6.7 E-6	
W-16-D	W-16-D-4a	10	---	---	---	28.76	1.51	2.3 E-5	
<u>Surface Soils</u>									
Loc 3	Loc. 3 S-1	3-9"	N.P.	N.P.	N.P.	8.47	1.47	1.0 E-2	SP-SM or SM
S-47	S-47	3-9"	N.P.	N.P.	N.P.	6.91	1.43	2.7 E-3	SP-SM
Loc 5	Loc. 5-1	6-9"	N.P.	N.P.	N.P.	8.49	1.43	2.4 E-4	SP-SM
Loc 6	Loc. 6-1	6-9"	N.P.	N.P.	N.P.	6.92	1.45	1.9 E-3	SP-SM
Loc 12	Loc. 12-1	3-9"	N.P.	N.P.	N.P.	10.15	1.25	2.0 E-2	SP-SM
S-15	S-15-0	Surface	N.P.	N.P.	N.P.	15.44	1.82	3.7 E-6	SM
S-18	S-18-0	Surface	21.07	27.50	6.43	17.63	1.72	< 1.0 E-5	SM
S-19	S-19-0	Surface	25.53	31.16	5.36	13.50	1.50	5.1 E-2	SW or SP
S-22	S-22-0	Surface	23.31	31.15	7.84	23.11	1.49	2.7 E-4	ML
S-24	S-24-0	Surface	N.P.	N.P.	N.P.	5.48	1.13	6.0 E-2	SM
S-25	S-25-0	Surface	N.P.	N.P.	N.P.	8.88	1.50	1.2 E-2	SM
S-26	S-26-0	Surface	20.24	23.73	3.47	6.16	1.72	3.1 E-2	SM
S-28	S-28-0	Surface	N.P.	N.P.	N.P.	8.60	1.52	2.8 E-3	SM
S-31	S-31-0	Surface	20.30	24.00	3.70	5.80	1.24	2.1 E-5	ML
S-33	S-33-0	Surface	17.90	22.65	4.75	8.87	1.38	1.5 E-2	ML
S-36	S-36-0	Surface	22.30	27.38	5.08	10.77	1.54	3.5 E-5	ML
S-51	S-51-0	Surface	N.P.	N.P.	N.P.	16.28	1.75	9.5 E-2	SM

1) Vertical permeability measured in laboratory parameter (ASTM D2434, 1974)

2) The formula for converting cm/sec to ft/day is as follows:

$$(1 \text{ cm/sec}) \frac{60 \text{ sec}}{\text{min}} \frac{60 \text{ min}}{\text{hr}} \frac{24 \text{ hrs}}{\text{day}} \frac{1 \text{ ft}}{30.48 \text{ cm}}$$

3) Soil types defined on Figure D4-1, Appendix D4

N.P. = Nonplastic as defined by ASTM D424

--- = Not analyzed

TABLE 4.2-2

PHYSICAL PROPERTIES OF ALLUVIUM

Well or Boring	Sample No.	Depth (feet)	Plastic Limit	Liquid Limit	Plasticity Index	Water Content % (q/q)	Dry Density (g/cm ³)	Vertical ¹ Permeability (cm/s) ²	Soil ₃ Type
B-5	B-5-23.0-0	23.0	N.P.	N.P.	N.P.	48.28	1.34	1.7 E-4	SP-SM
B-6	B-6-23.5-0	23.5	28.95	31.23	2.28	47.98	1.09	3.5 E-5	ML
B-8	B-8-33.5-0	33.5	28.25	37.22	8.97	48.24	1.10	< 1.0 E-5	ML
B-10	B-10-30.1-0	30.1	N.P.	N.P.	N.P.	30.67	1.40	8.7 E-3	SP-SM
B-10	B-10-60-0	31.6	N.P.	N.P.	N.P.	34.40	1.36	1.6 E-2	SM
W-12-0	W-12-0-10	35	---	---	---	43.98	1.23	6.1 E-5	
W-12-0	W-12-0-11	35	N.P.	N.P.	N.P.	---	---	---	ML
W-12-0	W-12-0-14	47	---	---	---	49.32	1.17	6.6 E-8	
W-12-0	W-12-0-15	47	30.27	41.59	11.32	---	---	---	ML
W-12-0	W-12-0-19	65	---	---	---	43.99	1.24	5.2 E-7	
W-12-0	W-12-0-22	65	34.98	40.12	5.14	---	---	---	ML
W-12-0	W-12-0-23	65	---	---	---	50.39	1.14	2.9 E-6	
W-12-0	W-12-0-24	65	37.41	40.68	3.27	---	---	---	ML
W-12-0	W-12-0-27	80	---	---	---	39.31	1.30	3.9 E-6	
W-12-0	W-12-0-29	80	29.72	31.79	2.07	---	---	---	ML
W-12-0	W-12-0-32	95	---	---	---	39.86	1.27	2.6 E-6	
W-12-0	W-12-0-34	95	31.31	33.84	2.53	---	---	---	ML
W-15-0	W-15-0	17.1-17.6'	N.P.	N.P.	N.P.	28.86	1.38	1.9 E-3	SP
W-15-0	W-15-0-20.4-0	20.4	N.P.	N.P.	N.P.	20.06	1.62	1.1 E-2	SP-SM
W-15-0	W-15-0-25.2-0	25.2	N.P.	N.P.	N.P.	30.99	1.37	8.0 E-3	SP
W-16-S	W-16-S-1	5	74.31	90.29	15.98	---	---	---	ML
W-16-0	W-16-0-4	10	N.P.	N.P.	N.P.	---	---	---	SM
W-16-0	W-16-0-7a	20	---	---	---	21.10	1.47	4.8 E-4	
W-16-0	W-16-0-7	20	N.P.	N.P.	N.P.	---	---	---	SM or SP-SM
W-16-0	W-16-0-10a	30	---	---	---	68.91	0.94	2.7 E-6	
W-16-0	W-16-0-11		36.81	44.58	7.77	---	---	---	ML
W-16-0	W-16-0-16a	50	---	---	---	36.95	1.36	7.8 E-7	
W-16-0	W-16-0-16	50	26.97	31.17	4.20	---	---	---	ML
W-16-0	W-16-0-20a	65	---	---	---	33.74	1.42	2.3 E-5	
W-16-0	W-16-0-20	65	25.30	26.54	1.24	---	---	---	ML

1) Vertical permeability measured in laboratory parameter (ASTM D2434, 1974)

2) The formula for converting cm/sec to ft/day is as follows:

$$(1 \text{ cm/sec}) \left(\frac{60 \text{ cm}}{\text{min}} \right) \left(\frac{60 \text{ min}}{\text{hr}} \right) \left(\frac{24 \text{ hrs}}{\text{day}} \right) \left(\frac{1 \text{ ft}}{30.48 \text{ cm}} \right)$$

3) Soil types defined on Figure D4-1, Appendix D4

N.P. = Nonplastic as defined by ASTM D424

--- = Not analyzed

4.2.2.3 Columbia River Basalt

In the Portland area, the Columbia River Basalt consists of 12 to 14 flows of basalt. The flows, which date from the Miocene age, are jointed and usually have rubbly or vesicular tops which contain most of the ground water. Often they are separated by a few inches or feet of sedimentary deposits (siltstone to sandstone). Some of the flows are weathered to a depth of a few feet. The basalt is estimated to be in excess of 500 feet in thickness beneath the site (Trimble 1963).

In the site area, the basalt dips to the northeast from the Portland Hills anticline into the Portland Basin. Basalt crops out at the base of the hills southwest of the site at about elevation 35 feet. Beneath the site it slopes from elevation -7 feet in well W-6B to -64 feet in well W-11B. The configuration of the surface of the basalt beneath the site is shown in Figure 4.2-5.

The basalt encountered during this investigation is thought to belong to the Frenchman Springs Member of the Columbia River Basalt Group. It is medium-grained (crystals 1 to 2 millimeters across), and has a porphyritic texture. Fine to coarse basalt gravel locally overlie the basalt. These gravels, which are occasionally vesicular, are subround to subangular. Based on the geophysical logs of wells W-6B and W-11B (Appendix D2), the upper section of the basalt is thought to be fractured and jointed.

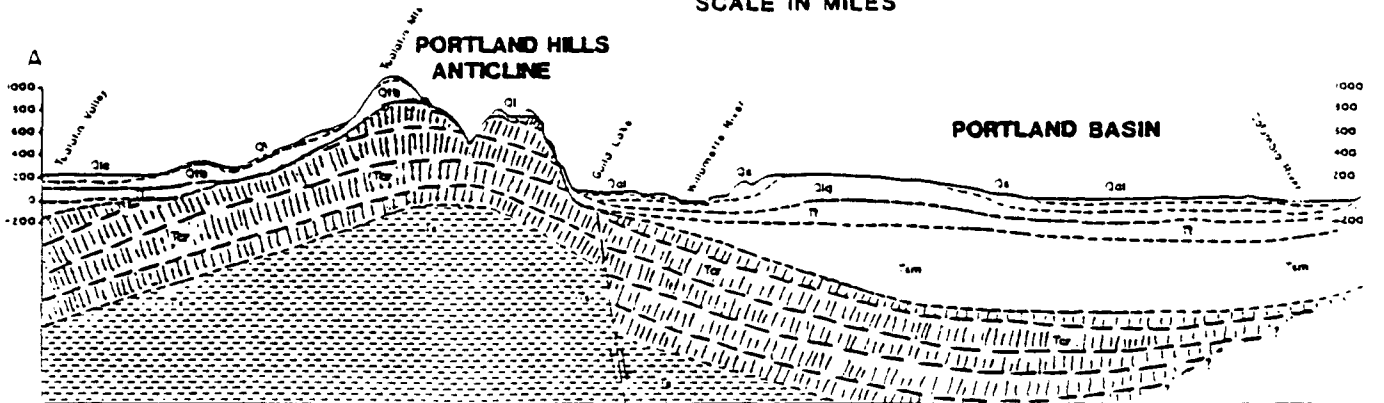
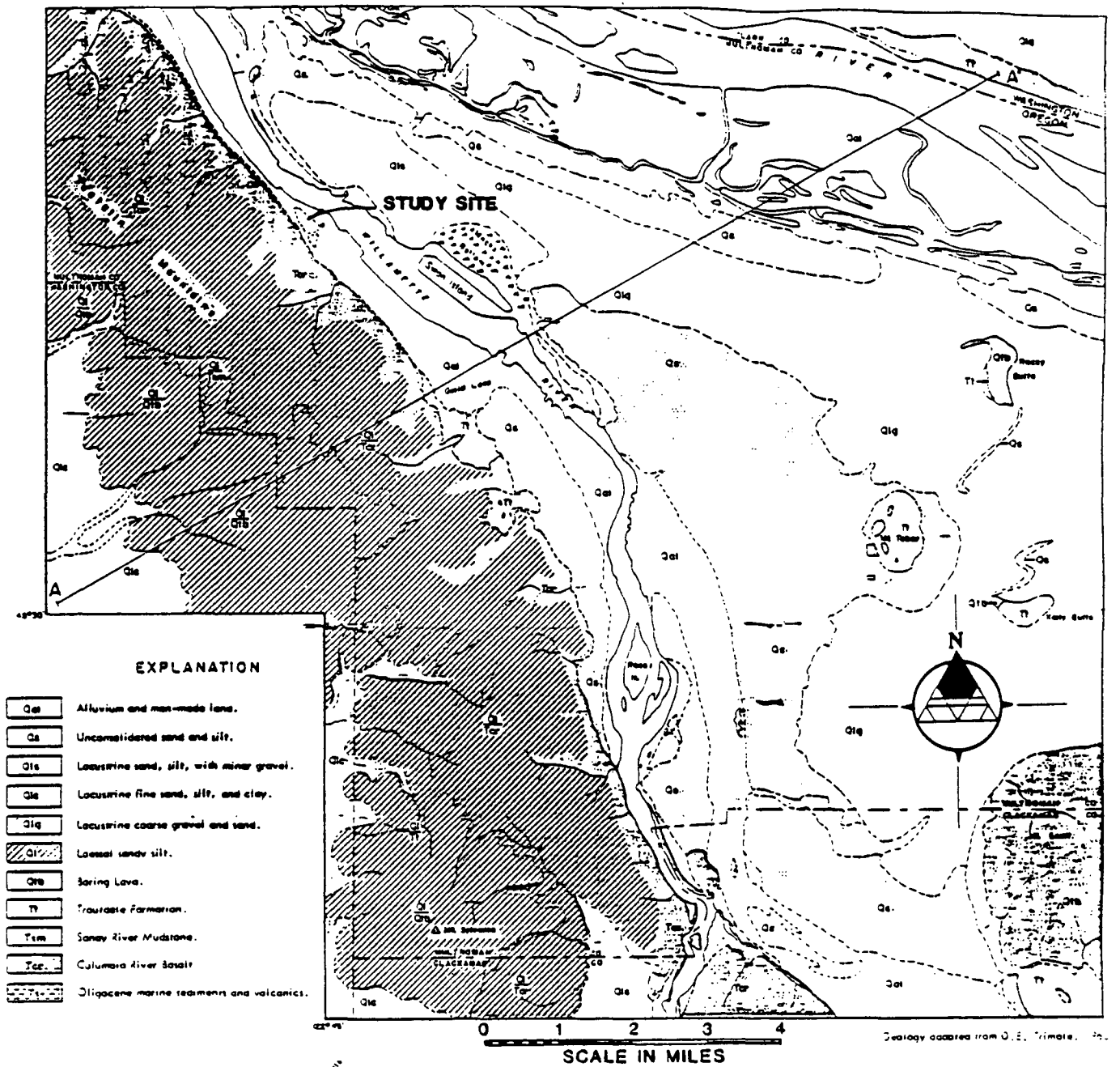
4.2.2.4 Doane Lake and Willamette River Sediments

The Doane Lake sediments have been identified on site by drilling boreholes through the filled portions of Doane Lake. The sediments are generally clay and silt, which represent lacustrine and fluvial depositional environments. Occasional lenses of fine-grained sands are also present in the Doane Lake sediments.

Sediment samples from the existing lake-bottom surficial deposits were collected by Dames & Moore. The sediments were generally a black "muddy clay" with abundant organic matter, except for those collected on the Schnitzer/Liquid Air property. These samples contained large amounts

of lime (added to the pond as a pH treatment) and were generally a white to gray "muddy clay". Grain size distribution analyses of the Doane Lake sediment samples indicate the sediments consist of clayey silts to fine grain silty sand (Appendix D). The sediment sampling procedures are discussed in Appendix A.

Willamette River sediment samples were obtained in areas upstream and downstream of an outfall draining the Gould site. Grain size analyses of the sediment samples indicate the samples consist predominantly of sand with minor amounts of gravels and silts (Appendix D). The sediment sampling procedures are discussed in Appendix A.



SOURCE: SCHLICKE AND DEACON, 1964

NL IND, INC./GOULD, INC.
REMEDIAL INVESTIGATION

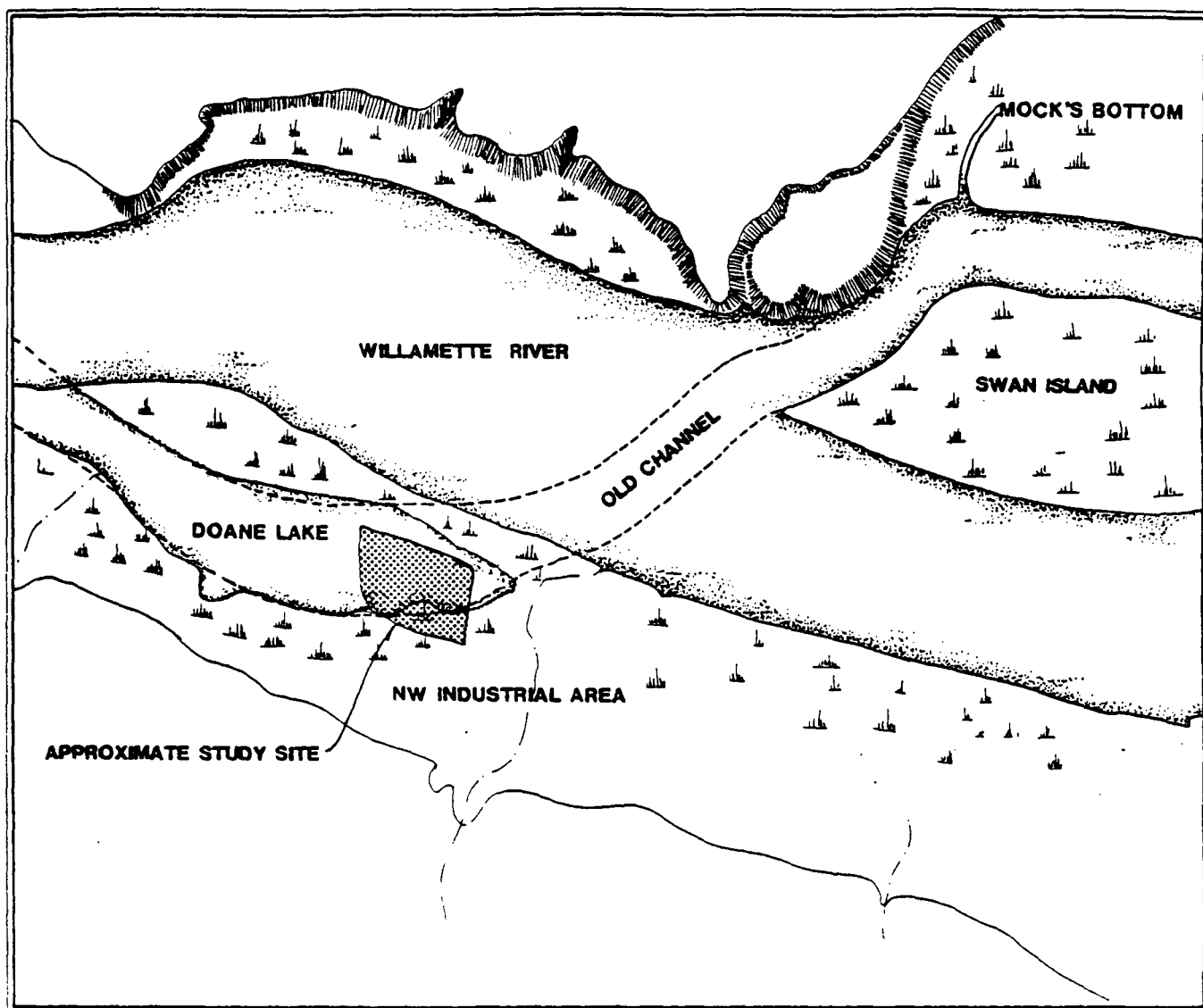
REGIONAL GEOLOGY

FIG. 4.2-1

DAMES & MOORE

11831-034

SCOEPAA00004196



0 1000
SCALE FEET

AFTER 1880 UNITED STATES COAST &
GEODETIC SURVEY MAP, COURTESY OF
OREGON HISTORICAL SOCIETY



11831-034

NL IND, INC./GOULD, INC.
REMEDIAL INVESTIGATION

1880 TOPOGRAPHY

FIG. 4.2-2

DAMES & MO

SCOEP00004197

4.3 HYDROLOGY

4.3.1 Precipitation

Precipitation data were collected from the Portland International Airport (PIA) for the period of August 1, 1986 through February 3, 1987, and from downtown Portland for the period of October 1 to December 7, 1986. PIA records for August, September, and November are from National Oceanic and Atmospheric Administration (NOAA) summaries. All other records are National Weather Service data as reported in the Daily Oregonian.

The precipitation data are tabulated in Appendix D3.1. The table shows daily totals for the PIA and downtown Portland, as well as cumulative data for the PIA. Comparisons of the PIA and downtown Portland data indicate the precipitation rates are similar between the two stations.

During the period of study, virtually no rain fell between August 1 and August 30, 1986. Approximately 4.5 inches fell between September 1 and September 30, 1986. No measurable rain fell from September 30 to October 18, 1986, while approximately 18 inches fell from October 18, 1986 to February 1, 1987.

4.3.2 Surface Drainage Patterns

The surface drainage patterns at the Gould site are shown in Figure 4.3-1. Water from East Doane Lake remnant flows northward beneath N.W. Front Street and discharges into the Willamette River.

The East Doane Lake remnant receives runoff from the Rhone-Poulenc properties, from the Schnitzer/Liquid Air property, from the ESCO property, and eastern portions of the scrap yard.

The West Doane Lake remnant receives runoff from the ESCO property and from the western portion of the scrap yard.

4.3.3 Doane Lake Remnants

The East and West Doane lakes are remnants of a lake that was gradually filled over the years so that only relatively small remnants now remain. The history of the fill activities are discussed in Section 3.2.

East Doane Lake is located on the Gould and Schnitzer/Liquid Air properties. Lake depths vary from approximately 13 feet on the western part to approximately 4 feet in the eastern end of the lake.

West Doane Lake is located along the railroad right-of-way on the west edge of the Rhone-Poulenc scrap yard. Lake depths are shallow and range from approximately 5 feet to less than 3 feet. An aerator is located at the southern end of the remnant.

4.3.4 Willamette River

The Willamette River is located north of the Gould site (Figure 4.2-1). This section of the river is subject to non-saline tidal effects which are transmitted from the Pacific Ocean via the Columbia River.

River level changes for the Willamette River were obtained from the U.S. Army Corps of Engineers, for the period from August 1, 1986 through February 3, 1987 at the Morrison Street Bridge gauging station which is approximately 6 river miles upstream from the site; the daily maximum and minimum river levels are presented in Appendix D3.1.

The daily ranges of river stage, summarized in Appendix D3.1, are plotted in Appendix D3.4. A correction of +2.92 feet has been made to the raw data to adjust them to the City of Portland datum. The river stage reflects a variety of influences in addition to rainfall and snowmelt, including tide, irrigation withdrawal, reservoir releases and captures, and power generation.

The tidal influences are reflected in continuous river elevations recorded by the National Weather Service (NWS) at Portland Harbor and

subsequent plotting of slack water highs and lows (Stiger 1987). A review of these plots from August 1986 to March 1987 indicate the river level fluctuates as much as 4 feet within a 24-hour period. Tidal influences on river elevations are as yet unpredictable by the NWS and have been known to be negated when river elevations exceed 11 feet (during periods of high flow). Low river stages on weekends can be attributed at times to reduced releases from upstream reservoirs for electricity generation. Local rainfall is reflected only in the general sense that the river is usually at high stage during the rainy season, and is usually low during the dry season.

The lack of a strong correlation between local rainfall and river stage is shown on Figure D3.3-2, Appendix D3.3. Very little correlation is apparent through the summer and early fall. However, after mid-November most, but not all, storms were followed by a rise in the river at Portland. Similarly, not all rises in the Willamette River were preceded by rainfall in Portland. This is illustrated by Figure D3.3-2, Appendix D3-3, which shows the daily modal river stage, together with rainfall data for the previous five days.

4.4 HYDROGEOLOGY

4.4.1 Regional Hydrogeology

Within the area near the site, four geologic units that act as regional aquifers are present. These are the Columbia River Basalt, the Troutdale Formation, late Pleistocene glacial flood deposits, and Holocene alluvium, from oldest to youngest. In the Portland-Vancouver area the oldest of these units, the Columbia River Basalt, and underlying rocks have been warped down into the Willamette Lowland (Figure 4.2-1). The Portland Hills anticline forms a structural high that separates the east part of the Lowland (Portland Basin) from the west part (Tualatin Valley). The basin was subsequently filled with sand and gravel of the Sandy River Mudstone, Troutdale Formation and Pleistocene flood deposits (sand, gravel and silt). After the filling of the basin, the Willamette and Columbia rivers cut down through the flood deposits and Troutdale to about 150 feet below their present depths. As sea level rose about 300 feet (at the end of the Pleistocene) the rivers backfilled these deep canyons with alluvial deposits of gravel, sand, silt and clayey silt.

The basalt forms the main regional aquifer. It receives recharge from the uplands adjacent to the Portland Basin where the edges of the individual flows are exposed, or outcrop. Because the basalt is overlain by the low permeability Sandy River Mudstone, water in this aquifer becomes confined in the central part of the Basin. Discharge from the basalt is largely to: (1) the river alluvium where the rivers have incised to that depth; (2) water wells; and (3) slow leakage to the Sandy River Mudstone.

Like the basalt, the Troutdale Formation receives recharge from the adjacent uplands where the uptilted edges of the strata are exposed. Local artesian conditions may occur in the Troutdale formation, which are related to discontinuous lenses of lower permeability materials. Discharge is largely to wells and the Columbia River. The Troutdale is not present immediately beneath the Gould site, but likely occurs east of the site beneath the Willamette River (Figure 4.2-1).

Pleistocene flood deposits do not occur within about 1/2 mile of the Gould site. They are, thus, not of significance to this investigation.

The alluvial deposits that line the Willamette river channel are recharged directly by precipitation, by bank storage, and by discharge from the Basalt, Troutdale and flood deposits. The alluvium is internally complex and, in aggregate, consists of numerous individual aquifers and aquitards. Consequently, hydrologic conditions within the alluvium it vary considerably from place to place and with the season. Discharge from the alluvium is generally to the river although, locally, discharge to wells and downward leakage to older rocks may occur.

4.4.2 Site Hydrogeology

4.4.2.1 Overview

The site hydrostratigraphy includes unconsolidated fill and alluvial deposits overlying basalt flows. The fill consists predominately of sands and gravels, silts, and an abundance of slag, bricks, metal parts, and battery casings. The alluvial deposits consist predominantly of clays, silts, and sands with the silt content generally increasing with depth. The alluvial deposits form alternating layers of thinly bedded and interfingering lenses. The basalt flow beneath the fill and alluvial deposits is thought to be fractured and weathered. Ground water occurs in the fractured and weathered portions of the basalts.

The fill and alluvial deposits form an interconnected, heterogeneous, and anisotropic aquifer. Heterogeneity indicates that the hydraulic conductivity of the aquifer is dependent on the location within the aquifer. For instance, the hydraulic conductivity measured within a layer of the fine-grained materials would be lower than the hydraulic conductivity measured within a layer of coarse-grained materials.

Anisotropy indicates that the hydraulic conductivity of the aquifer is dependent on the direction of measurement at any point in the aquifer. For example, the alluvial deposits beneath the site consist of layers of fine- and coarse-grained materials, each possessing a unique value of

hydraulic conductivity. If the layers are horizontal, any single layer with a relatively low hydraulic conductivity causes vertical flow to be retarded, but horizontal flow can occur easily through any stratum of relatively high hydraulic conductivity (Todd 1980).

The fill and alluvial water-bearing zones are believed to be generally unconfined, however due to the layering, heterogeneity, and anisotropy there may be locally confined conditions within the aquifers.

Four water-bearing units are identified beneath the site. These units are the fill, the upper alluvial, the lower alluvial, and the basalt water-bearing units. The relationships of these units are presented in conceptual hydrogeologic cross-sections and flow nets shown in Figures 4.4-1 through 4.4-8. Figures 4.4-1 through 4.4-4 show the water levels and flow line relationships for a cross-section oriented north to south. Figures 4.4-5 through 4.4-8 show the water levels and flow line relationships for a cross-section oriented east to west. The locations of the cross-sections are shown on Figure 4.2-3. The water levels shown were measured on October 23, 1986 and February 3, 1987.

The equipotential values and flow nets interpolated from the water level elevation contour maps of each water-bearing unit are discussed below. The total hydraulic head in the fill unit represents the phreatic surface. The total head value for the upper and lower alluvial water bearing units are represented at the base of the units. As shown in the flow nets, there is a significant component of downward flow.

The hydraulic properties and material types of the water-bearing formations are highly variable; they are described more fully below.

4.4.2.2 Fill Water-Bearing Unit

This unit is approximately 25 feet deep and consists primarily of discontinuous layers of materials that include sands and gravels, silty sands, and a wide variety of debris and rubble (see Section 4.2.2).

The fill water-bearing unit is hydraulically connected to the East and West Doane lakes and the alluvial water-bearing unit beneath it. Due to the low permeability of the silts in the alluvium, which become more prominent from south to north across the site, the fill water-bearing unit becomes increasingly perched above the alluvial aquifer. At well W-11, the piezometric surface of the fill water-bearing unit averages 14 feet higher than the piezometric surface of the upper alluvial water-bearing unit, whereas at well W-1, the two piezometric surfaces average 1 to 2 feet difference.

Contours of ground-water level elevations in wells completed within the fill water-bearing zone are presented in Figures 4.4-9 and 4.4-10 for water levels measured on October 23, 1986 and February 3, 1987, respectively. The contours are presented to show variations in ground-water levels and indicate that ground-water flow within the fill is predominately northward. This trend has also been observed in previous studies near the site (Dames & Moore 1983, and Camp, Dresser & McKee 1987). The February 3, 1987 ground-water level elevation contours (Figure 4.4-10) show the presence of a ground-water mound near well W-11S. This mound is believed to be the result of infiltrated rainfall that has penetrated the clay cap over the ESCO property. The mound developed after a period of heavy rainfall on January 30 through February 1, 1987. The temporal formation of ground-water mounds create local reversals of hydraulic gradients that temporarily alter ground-water flow directions and velocities.

Buried utility lines located parallel to N.W. Front Street intercept the upper portion of the water table in the fill water-bearing unit. The bottom of the utility lines are approximately 20 feet below ground surface and, as shown on Figures 4.4-9 and 4.4-10, ground water in the utility lines flows northward towards a pump station located on

the northern end of the site. Typically, utility trenches are back-filled with sands and gravels during construction, indicating that the utility line trench may present a zone of high permeability and a preferred ground-water pathway.

Ground-water level fluctuations of over four feet have been recorded at well W-11S (see Hydrograph of W-11S, November 29, 1986 to March 21, 1987; Appendix D3.4). The ground-water level fluctuations are probably caused by precipitation and river level changes (Section 4.4.3.1).

4.4.2.3 Alluvial Water-Bearing Units

Upper Alluvial Water-Bearing Unit: The upper alluvial water-bearing unit is approximately 20 to 30 feet thick and consists primarily of interfingering layers and lenses of thinly bedded clays, silts, and sands. The individual layers and lenses are generally discontinuous beneath the site.

The contours of ground-water level elevations in wells completed within the upper alluvial water-bearing zone are presented in Figures 4.4-11 and 4.4-12 for water levels measured on October 23, 1986 and February 3, 1987, respectively. The contours indicate that lateral ground-water flow within this unit is predominately northward. This same trend has been reported in previous studies conducted near the site (Dames & Moore 1983 and Camp Dresser & McKee 1987).

The upper alluvial water-bearing unit is hydraulically connected with East and West Doane lakes, the lower alluvium, the fill aquifer and the Willamette River. The piezometric surface of the upper alluvial water-bearing unit, in general, is slightly higher than that of the lower alluvial aquifer. This difference is caused by downward flow, as well as the occurrence of less permeable zones between the upper and lower alluvial units. Beneath the ESCO property and the northern part of the Gould property, a ground-water trough exists. The axis of the trough is oriented north-south from well W-11 past well PP-8 and appears to follow a zone of fine sand that exhibits higher permeabilities than the surrounding silts (Figures 4.4-11 and 4.4-12; Plate 4-C, Cross

Section I-I'). The ground-water trough may be the result of increased flow rates through the sand layer, reduced infiltration as the result of asphalt at the Gould site, and discharge from the alluvial water-bearing unit to the basalt water-bearing unit.

Lower Water-Bearing Unit: The lower alluvial water-bearing unit is approximately 20 to 40 feet thick and consists of materials similar to the upper alluvial water-bearing zone. This unit is generally siltier than the overlying upper alluvial water-bearing zone.

The contours of ground-water level elevations in wells completed within the lower alluvial water bearing zone are presented in Figures 4.4-13 and 4.4-14 for water levels measured on October 23, 1986 and February 3, 1987, respectively. The contours indicate that lateral ground-water flow within this unit is predominately northward.

The upper and lower alluvial water-bearing units comprise one water-bearing unit in the alluvium. The distinction between the two units is somewhat arbitrary, as there may, in fact, be several smaller water-bearing zones within the alluvium. However, in the lower alluvium the ground-water trough identified in the upper alluvium is not as pronounced, and the soils become more uniformly silty. The distinction between upper and lower alluvial water-bearing units is useful in the description of the contaminant distribution in Section 4.5.

Ground-water level fluctuations of approximately 2 feet have been recorded at well W-11I (Table D3.2-1). The fluctuations are probably caused by precipitation and river level changes.

4.4.2.4 Basalt Water-Bearing Unit

Ground-water is encountered in the fractured and weathered portions of the basalt. The ground-water may be confined by the overlying fill and upper and lower alluvial water-bearing zones. The fractured and jointed nature of the rock affect its horizontal and vertical permeability. The basalt aquifer beneath the northern part of the site is slightly artesian and discharges water to the overlying alluvial aquifer, as evidenced by water levels at well W-11. The aquifer is recharged by

the alluvium at the southern end of the site, as evidenced by water levels at well W-6.

Ground-water level fluctuations of over 2 feet have been recorded at well W-11B (see Hydrograph W-11B December 18, 1986 to March 18, 1987; Appendix D3.4). The ground-water level fluctuations are due to precipitation and river level change.

4.4.3 Hydrogeologic Parameters

4.4.3.1 Water Level Fluctuations

Ground-water levels in wells W-11S and W-11B were recorded continuously from November 1986 to March 1987 (Appendix D3.4). The records of precipitation and Willamette River stage data are presented in Appendices D3.1 through D3.3. Examination of these hydrographs, and data from precipitation and the Willamette River level records indicate that during this period, ground-water level fluctuations were caused primarily by precipitation and river level fluctuations. Precipitation does not appear to have an immediate effect on ground-water levels at wells W-11S and W-11B, but does appear to infiltrate and elevate the ground-water levels within a few days.

Ground Water

Ground-water elevations also appear to be controlled to a great extent by Willamette River fluctuations. Periods of high flow within the Willamette River (corresponding to periods of high rainfall) appear to decrease the hydraulic gradient and discharge of ground water into the river. As the river level drops, ground-water discharge to the river will increase and lower the ground-water level.

The four water-bearing units appear to be hydraulically interconnected. Because of this, the aquifer distinctions become somewhat arbitrary. Designation of separate aquifers will not influence the interpretation of flow conditions on site because the aquifer designation will not alter observed head relationships between locations within the sediments. The hydraulic interconnection is evidenced by similar

water level fluctuations in all water bearing units (Figures D3.3-1 to D3.3-9, Appendix D). Table 4.4-1 shows correlations between the water level fluctuations in the basalt, alluvial, and fill water-bearing units, East and West Doane lakes, the Willamette River and average daily barometric pressure from wells W-6 and W-11. The correlation coefficient values range between +1.0 to -1.0 and are a relative means of comparing the positive or negative correlation between variation in sequences of data. A correlation coefficient of +1.0 indicates that the two sequences compared vary in exactly the same manner. A correlation coefficient of -1.0 indicates that the two sequences compared vary in exactly the opposite manner. A correlation coefficient of zero indicates no statistical correlation exists between the compared data sequences.

TABLE 4.4-1
WATER LEVEL CORRELATIONS

Water Level Correlations	Correlation Coefficient
W-6B (basalt) vs W-6D (lower alluvium)	.967
W-6D (lower alluvium) vs W-S (upper alluvium)	.998
W-6B vs Willamette River stage	.706
W-6D vs Willamette River stage	.768
W-6D vs East Doane Lake stage	.933
W-6D vs average daily barometric pressure	-.340
W-11B (basalt) vs W-11D (lower alluvium)	.978
W-11D (lower alluvium) vs W-11I (upper alluvium)	.984
W-11D (lower alluvium) vs W-11S (fill)	.949
W-11D vs Willamette River stage	.840
W-11B vs Willamette River stage	.862
W-11D vs East Doane Lake stage	.871
W-11D vs average daily barometric pressure	-.300
East Doane Lake stage vs West Doane Lake stage	.935

As can be seen, the water levels are highly correlated with each other (which can also be verified by inspection of Figures D3.3-1 to D3.3-9, Appendix D) at each well and with the lake water levels. This suggests that the lakes and water-bearing units are responding to similar driving mechanisms and/or are influencing each other. As shown in Figure 4.4-15, ground-water levels and lake levels rise in response to

rainfall. The water level responses to rainfall inputs become more pronounced later in fall and winter over the period of record. This reflects the fact that the unsaturated zone transmits infiltrated rainfall to the ground water more efficiently after the soil reaches field capacity and that runoff to the lakes is also enhanced after the soil reaches field capacity or becomes saturated.

The strong correlation between lake levels and ground-water levels indicates that the lakes are important sources of recharge or discharge. This concept is further verified by inspection of the cross sections in Figures 4.4-7 and 4.4-8. As shown in Figures 4.4-7 and 4.4-8, water level elevations in East Doane Lake are above the water level elevations in the fill, alluvial and basalt water-bearing units. This condition exists throughout the period of record. The water level elevation in West Doane Lake is also above the water level elevations in the alluvial and basalt water-bearing units, but is lower than the water level elevation in the fill water-bearing unit, which indicates ground water from the fill discharges into West Doane Lake.

The immediate response of the ground-water levels and lake levels to each other indicates that ground water and the lakes are all hydraulically connected and the water-bearing units are locally confined or semi-confined.

The correlation between the Willamette River levels and ground-water levels indicate they are hydraulically connected. Ground water flows toward the Willamette River, although the slope of the hydraulic gradient will change as river level fluctuations alter the ground-water levels.

Surface Water

The Willamette River is affected by tidal influences via the Columbia River. Data supplied by the National Weather Service show these tidal influences raise and lower the Willamette River as much as 4 feet over a period of 24-hours (Stiger 1987). The tidal fluctuations will affect the ground-water levels by changing the water levels in the Willamette River.

Surface water fluctuations in East and West Doane lakes are the result of precipitation, including direct precipitation on the lakes, collection of surface runoff, and indirectly by the rise of upgradient ground water which discharges to the lakes.

Ground-water level elevations and hydrographs of the water levels are presented in Appendix D3, Table D3.2-1 and Figures D3.3-1 through D3.3-9.

4.4.3.2 Hydraulic Gradients

Water levels measured throughout the study were compared to determine variation of hydraulic gradients and direction of hydraulic gradients. We felt that water levels measured on October 23, 1987 and water levels measured on February 3, 1987 were representative of the range of water levels and gradient variation observed on site throughout the study.

Horizontal hydraulic gradients for water levels measured October 23, 1986 in wells completed in the fill water-bearing zone varied from about 3 feet in 400 feet (0.75 percent) to about 4 feet in 1,500 feet (0.27 percent). The predominant direction of ground-water flow is northward. The hydraulic gradients in the southwest part of the site may be affected by the Rhone-Poulenc ground-water withdrawal/recovery system during the dry time of year (however, this has not been investigated).

Horizontal hydraulic gradients for water levels measured October 23, 1986 in wells completed in the upper alluvial water-bearing zone varied from nearly flat to about 12.5 feet in 700 feet (1.79 percent). Hydraulic gradients in the upper part of the alluvial aquifer are locally complex and appear to be affected by the placement of screens in several different stratigraphic intervals. Regardless of these complexities, gradients for the alluvial aquifer are generally to the north-northwest, with a northeast component from East Doane Lake towards N.W. Front Street and a northwest component from East Doane Lake towards West Doane Lake.

Horizontal hydraulic gradients for water levels measured October 23, 1986 in wells completed in the lower alluvium wells are generally uniform and to the north at about 12 feet in 1,300 feet (0.90 percent) (Figure 4.4-13). A northeast deflection of the hydraulic gradient near well W-8D may reflect the influence of infiltration from the West Doane Lake remnant or the rise of the basalt bedrock in that area.

Horizontal hydraulic gradients in the fill and alluvial aquifer for water levels measured on February 3, 1987 are generally similar to those during October 23, 1986. However, as shown in Figure 4.4-10, a groundwater mound is inferred at well W-11S. This mound may be caused by rainfall infiltration, as discussed in Section 4.4.2.2.

The differences in water level elevation between October 23, 1986 and February 3, 1987 for the fill, upper alluvial, and lower alluvial water-bearing zones are shown in Figures 4.4-16 through 4.4-18. These figures provide an estimate of the areal distribution and magnitude of variation of water levels between these two measurement periods.

Downward vertical hydraulic gradients exist beneath the site. The vertical gradients are determined from the water levels in closely spaced wells that monitor the water pressure in the fill, upper alluvial, and lower alluvial water-bearing zones. Hydrographs of 10 well clusters for the period between August 16, 1986 through February 12, 1987 are shown in Appendix D3, Figures D3.3-3 through D3.3-9. Precipitation records are also plotted on these hydrographs to illustrate the effects of rainfall on the water levels. In general, the shallow wells have water levels that are higher in elevation than water levels in wells completed in deeper zones.

The areal distribution of downward hydraulic gradients between the fill and alluvium are shown in Figure 4.4-19 for January 13, 1987. The vertical hydraulic gradients in the well clusters are generally downward between the fill and the alluvium.

The two well clusters (W-6 and W-11) which monitor the water levels in the alluvial and basalt water-bearing zones show that vertical

hydraulic gradients exist between the alluvium and basalt. The water levels in well cluster W-6 indicate that a downward gradient exists between the alluvium and the basalt.

The water level in the basalt at well cluster W-11 has generally been about 0.3 to 0.5 feet above the water level in a well completed in the overlying alluvium. This indicates an upward hydraulic gradient exists between the alluvium and the basalt. It appears that the direction of vertical ground-water flow in the basalt reverses from downward near the Portland Hills to upward near the Willamette River. This change in vertical flow direction is consistent with that observed in other areas of the Portland Basin (Brown 1963; Hogerson & Foxworthy 1965).

4.4.3.3 Hydraulic Conductivity

The hydraulic conductivity of the water-bearing units beneath the site were estimated from in-situ slug test data for horizontal hydraulic conductivity (K_h). The K_h results were calculated by the Hvorslev Basic Time Lag method (Hvorslev 1951). The vertical hydraulic conductivity (K_v) values were measured in the laboratory on soil samples collected in-situ from soil borings. The hydraulic conductivity results are presented in Tables 4.2-1, 4.2-2, and 4.4-2).

The K_h values of the fill range from 10^{-5} to greater than 10^{-2} cm/sec. The estimated value of various soil types in the fill range from 10^{-3} to more than 10^{-2} cm/sec for sand, approximately 10^{-4} cm/sec for clayey silt to silt, 10^{-3} to 10^{-2} cm/sec for the battery casing fragments, and 10^{-3} to 10^{-2} cm/sec for the mat.

The K_v of the fill range from 3.7×10^{-6} to 3×10^{-2} cm/sec for the sandy material, average 2.7×10^{-4} cm/sec for the silt and range from 3.5×10^{-5} to 1.5×10^{-2} cm/sec for the "clay cap" on the ESCO property. Sieve analyses (Appendix D5) and permeability data indicate that the clay cap is actually a clayey silt to sandy silt.

The hydraulic conductivity of the alluvium was estimated from results of in-situ slug tests. The K_h values of the alluvium range from

TABLE 4.4-2

GOULD WELL PERMEABILITY DATA: MONITORING WELLS

WELL DESIGNATION	S I D	Kh [CM/SEC] 100:1	FORMATION MATERIAL
<hr/>			
BASALT AQUIFER			
W-11B	S	4E-04	BASALT
W-6B	S	3E-03	BASALT
ALLUVIUM AQUIFER			
RPW-1D	D	3E-03	SANDY SILT/SILTY SAND
W-8D	D	2E-03	80% SILT 20% SANDY SILT
RPW-5D	D	1E-03	SANDY SILT/SILTY SAND
W-1D	D	1E-04	SANDY SILT/SILTY SAND
W-3D2	D	7E-04	70% SILTY SAND 25% CLAYEY SILT 5% SILT
W-16D	D	2E-04	SANDY SILT/SILTY SAND
RPW-2D	D	3E-04	95% SAND 5% SILTY SAND
W-15D	D	1E-04	SILT
W-6D	D	6E-04	SAND
W-12D	D	1E-04	70% SILTY CLAY 30% SANDY SILT/SILTY SAND
RPW-3D	D	4E-03	SAND
RPW-4D	D	9E-04	60% SAND 40% SILTY SAND/SANDY SILT
W-2D	D	7E-06	55% SILTY SAND/SANDY SILT 45% CLAYEY SILT
W-11D	D	3E-04	CLAYEY SILT
PP-11	I	5E-05	66% SILTY SAND/SANDY SILT 34% SAND
W-12I	I	2E-06	55% SILT 45% SANDY SILT/SILTY SAND
PP-8	I	3E-05	SANDY SILT/SILTY SAND
W-3D	I	5E-05	SANDY SILT/SILTY SAND
W-10D	I	2E-03	80% SAND 20% SILTY SAND/SANDY SILT
W-16I	I	1E-05	CLAYEY SILT
W-9D	I	6E-06	65% SANDY SILT 35% FILL SILT WITH METAL FRAGMENTS
W-7D	I	2E-04	75% SAND 25% SANDY SILT/SILTY SAND
W-6S	I	4E-04	60% SILTY SAND/SANDY SILT 35% SILTY CLAY/CLAYEY SILT 5% SILT
W-15I	I	5E-04	SAND
W-11I	I	4E-04	80% CLAYEY SILT/SILTY CLAY 20% SILTY SAND/SANDY SILT
W-4D	I	4E-06	SANDY SILT/SILTY SAND
FILL AQUIFER			
W-7S	S	2E-02	BATTERY CASINGS
PP-6	S	2E-02	80% BATTERY CASINGS 20% SAND
W-12S	S	3E-04	SILTY SAND/SANDY SILT WITH SLAG GRAVEL
W-11S	S	2E-04	66% SAND 34% SILT
P-4	S	1E-04	SAND AND RUBBLE
P-2	S	7E-02	66% SAND 34% FILL (MATTE)
P-3	S	7E-04	SAND
W-16S	S	2E-03	60% SAND 40% SILT
P-1	S	2E-03	70% SAND 30% SILTY CLAY
W-15S	S	7E-03	30% FILL (GRAVEL) 20% SANDY SILT/SILTY SAND

less than 10^{-6} to more than 10^{-2} cm/sec. The K_h values of the sand have been estimated to range from 10^{-3} to 10^{-2} cm/sec. The sandy silt to silty sand is estimated to range from 10^{-6} to 10^{-3} cm/sec. The clayey silt to silty clay is estimated to range from 10^{-5} to less than 10^{-6} cm/sec. K_v values range from 10^{-8} to 10^{-2} cm/sec.

Hydraulic conductivity of the basalt ranges from 4×10^{-4} to 3×10^{-3} cm/sec (Table 4.4-2). The vertical permeability of the basalt is likely to be similar to the horizontal permeability due to the uniform fracture patterns that are typical of basalts.

Previous studies near the southern portion of the site show similar values of hydraulic conductivity (Dames & Moore 1983). The values estimated during this investigation are typical for clays, silts, fine to medium sands and mixtures of sand silts and clays.

4.4.3.4 Transmissivities

The transmissivity of an aquifer is defined as the product of the horizontal hydraulic conductivity (K_h) and the saturated thickness of the aquifer (D) and is expressed by the equation

$$T = (K) (D)$$

In order to estimate representative values for transmissivity for the water-bearing zones beneath the site, the saturated thicknesses and average hydraulic conductivities of the zones were identified.

The saturated thickness of the fill water-bearing zone increases from south to north. At well P-1, the saturated thickness of the fill averages approximately 10 feet and at well W-11S, averages approximately 14 feet.

The values of horizontal hydraulic conductivity measured in the fill show a wide areal variation of several orders of magnitude. A feasible means of estimating a representative value for the hydraulic conductivity of the aquifer is to calculate the geometric mean of the measured values. Using a geometric mean of 2.2×10^{-3} cm/s for the

horizontal hydraulic conductivity of the fill, the transmissivity at well P-1 is estimated to be $62 \text{ ft}^2/\text{day}$ and at well W-11S, $87 \text{ ft}^2/\text{day}$.

The transmissivity of the alluvium is estimated by considering the upper and lower alluvial zones as one unit. This is justified because the lithologic differences between the two units are not pronounced and the piezometric surfaces of the water-bearing units are nearly coincident.

The thickness of the alluvium ranges from approximately 40 feet at the southern end of the site to approximately 90 feet at the northern end. The geometric mean of the horizontal hydraulic conductivity values for the alluvium is $1.6 \times 10^{-4} \text{ cm/sec}$. This estimate was refined by recognizing that sands and silts are the two dominant soil types that were present in the alluvial deposits. The percentage of sand and silt in the alluvium was estimated from the geologic cross-sections (Plates 4A, B, C) and geometric mean values for the hydraulic conductivities of the sand and silt strata (as identified on Table 4.4-2) were calculated. The average K_h for the entire deposit was then estimated by calculating a weighted average. The calculated weighted average of K_h is $1.7 \times 10^{-4} \text{ cm/sec}$.

Using the weighted average K_h value, the transmissivity of the alluvial water-bearing zone at the southern end of the site was estimated to be approximately $20 \text{ ft}^2/\text{day}$ and at the northern end $43 \text{ ft}^2/\text{day}$.

No information concerning the depth of weathering and saturation is available for the basalt beneath the site. Therefore, it is not feasible to estimate the transmissivity of the basalt water-bearing zone.

4.4.3.5 Ground-Water Flow Velocity

The average linear ground-water flow velocity is estimated from Darcy's Law:

$$v = Ki/n$$

where

v = average linear ground-water velocity

K = hydraulic conductivity

i = hydraulic gradient

n = effective porosity (also referred to as specific yield)

The horizontal hydraulic gradients in the fill and the alluvial water-bearing zones range from nearly zero to approximately 0.01 ft/ft (1 percent). The horizontal hydraulic conductivity ranges from 10^{-2} to 10^{-3} cm/sec for the fill and 10^{-3} to 10^{-4} cm/sec for the alluvium.

By using the horizontal hydraulic gradient of 0.01 ft/ft and an assumed effective porosity of 0.20 (Todd 1980), the estimated, linear horizontal ground-water flow velocity in the fill ranges from 0.1 to 1 ft/day and 0.01 to 0.1 ft/day in the alluvium.

The vertical hydraulic gradients in the fill range from 0.01 to 0.045 ft/ft. The vertical hydraulic gradient in the alluvium ranges from nearly zero to 0.1 ft/ft. The direction of flow is downward. The vertical hydraulic conductivity in the fill ranges from 10^{-1} to less than 10^{-6} cm/sec with a geometric mean of 10^{-3} cm/sec. The K_v of the alluvium ranges from 10^{-2} to 10^{-8} cm/sec with a geometric mean of 10^{-5} cm/sec.

By using the geometric mean values of K_v for the fill and alluvium, the average, linear, vertical ground-water flow velocity in the fill ranges from 0.1 to 6 ft/day and nearly zero to 0.01 ft/day in the alluvium.

4.4.3.6 Annual Water Budget Analyses for the Fill Alluvial Aquifers

The purpose for estimating a water budget for the saturated fill and alluvial aquifers beneath the site is to identify the hydraulic parameters that control the ground-water flow system and to quantify the ground-water recharge and discharge beneath the site. The conceptual model of water budget analysis is presented in Figure 4.4-20.

Assumptions: The fill and alluvial aquifers are assumed in this analysis to function as one aquifer. It is also assumed that steady-state ground-water flow conditions prevail and as such, the ground-water recharge is equal to ground-water discharge.

Ground-water recharge has three components: 1) infiltration from precipitation; 2) infiltration from the surface water bodies; and 3) lateral inflow into the water-bearing units.

Ground-water discharge has two components: 1) leakage from the base of the water-bearing units into the underlying basalt; and 2) lateral outflow from the water-bearing units.

The conceptual model of the steady-state flow system and of the water budget analysis is shown in Figure 4.4-20.

Recharge: As mentioned above, recharge has three components: 1) infiltration from precipitation; 2) infiltration from East and West Doane lakes; and 3) lateral inflow into the water-bearing units.

The infiltration of precipitation was not measured at the site; however, estimates of annual recharge from rainfall for the Willamette Valley have ranged from 1.5 inches to 18 inches or more, and may average approximately 20 percent of rainfall (8 inches) for the region (State of Oregon, 1983).

Infiltration from East and West Doane lakes can be estimated by using Darcy's Law assuming an average depth in the lakes, a flow path length and a vertical hydraulic conductivity estimate.

The vertical hydraulic conductivity of the materials immediately beneath the lakes is assumed to be 10^{-5} cm/sec. The length of the flow path is assumed to be equal to the average depth of the fill below the lakes, approximately 15 feet.

Lateral inflow to the fill alluvial water-bearing unit is estimated from the average hydraulic gradients and hydraulic conductivities (K_h). The average K_h for the fill is 2.2×10^{-3} cm sec and the average hydraulic gradient is 0.01.

A weighted average lake depth is estimated from the surface area and average depth of each lake. The surface areas of East and West Doane lakes are approximately 200,000 ft² and 100,000 ft², respectively.

The average depths of East and West Doane lakes are 8.4 feet and 3.3 feet, respectively. The resulting weighted average lake depth is 6.7 feet.

Discharge: Ground-water discharge from beneath the site has two components: 1) leakage from the base of the alluvium; and 2) lateral outflow. Lateral outflow can be estimated using Darcy's Law, with average K_h values and hydraulic gradients in the same manner as the lateral inflow. Leakage from the alluvium into the basalt is estimated to range from 0.5 to 1.0 feet/year.

The area of interest is approximately 77 acres, which includes the surrounding properties of ESCO, Inc., Rhone-Poulenc, Inc., Schnitzer Investment Corp., Liquid Air Corp., American Steel Industries, and Gould, Inc.

Technical Approach: Lateral inflow, lateral outflow, and infiltration from the lakes is controlled by the geometry and hydraulic properties of the ground-water system. These parameters have been estimated, and are considered known for the purposes of the water budget analysis. Estimates of infiltration of precipitation and discharge to the basalt are uncertain, and will be evaluated using a parametric approach. The infiltration parameter will be varied between 5 and 20 inches annually in increments of 5 inches. The leakage rate to the basalt will be varied between .5 and 2 feet/year in increments of .5 feet. The sensitivity of the system to varying these two parameters will be evaluated by comparing the percent error between total recharge and total discharge.

Solution:

The water budget is calculated by:

$$Q1 + Q2 + Q3 - Q4 - Q5 = 0$$

Where

$Q1$ = infiltration rate from precipitation into the aquifer

Q2 = infiltration rate from the surface water bodies into the aquifer
 Q3 = lateral inflow rate into the aquifer
 Q4 = lateral outflow rate into the aquifer
 Q5 = leakage rate from the aquifer into the basalt

The water budget calculations are presented in Table 4.4-1.

Calculations:

Q1 - Rainfall Infiltration

<u>Case</u>	<u>Infiltration</u>	<u>Area</u>	<u>Volume</u>
1	5 inches/yr	3,060,000 ft ²	1,275,000 ft ³ /yr
2	10 inches/yr	3,060,000 ft ²	2,550,000 ft ³ /yr
3	15 inches/yr	3,060,000 ft ²	3,825,000 ft ³ /yr
4	20 inches/yr	3,060,000 ft ²	5,100,000 ft ³ /yr

*Note: Area is the area of interest (77 acres) minus the lake area, which is treated separately.

Q2 - Infiltration from Surface Water Bodies

Hydraulic Gradient = 0.45
 Hydraulic Conductivity = 10^{-5} cm/sec = 10.35 ft/year
 Total Area of lakes = 306,000 ft²

$Q = KiA$ (Darcy's Law)
 where
 Q = flow rate
 i = hydraulic gradient
 K = hydraulic conductivity
 A = area of recharge

$$Q = (10.35 \text{ ft/yr}) (0.45) (300,000 \text{ ft}^2) = 1,400,000 \text{ ft}^3/\text{yr}$$

Q3 - Lateral Inflow

Fill

Transmissivity = T = 62 ft²/day
 Width of flow = W = 1,440 feet
 Hydraulic Gradient = i = .005

$$Q = (62 \text{ ft}^2/\text{day}) (365 \text{ days/yr}) (1,440 \text{ feet}) (.005) = 162,000 \text{ ft}^3/\text{yr}$$

Alluvium

$$\begin{aligned}T &= 20 \text{ ft}^2/\text{day} \\W &= 1,440 \text{ ft} \\i &= .01\end{aligned}$$

$$Q = (20 \text{ ft}^2/\text{day})(365 \text{ days/yr})(1,440 \text{ feet})(.01) = 105,000 \text{ ft}^3/\text{yr}$$

Q4 - Lateral Outflow

Fill

$$\begin{aligned}T &= 87 \text{ ft}^2/\text{day} \\W &= 1,440 \text{ feet} \\i &= .005\end{aligned}$$

$$Q = (87 \text{ ft}^2/\text{day})(365)(1,440)(.005) = 229,000 \text{ ft}^3/\text{yr}$$

Alluvium

$$\begin{aligned}T &= 43 \text{ ft}^2/\text{day} \\W &= 1,440 \text{ feet} \\i &= .01\end{aligned}$$

$$Q = (43 \text{ ft}^2/\text{day})(365)(1,440 \text{ feet})(.01) = 226,000 \text{ ft}^3/\text{yr}$$

Q5 - Leakage to Basalt .

<u>Case</u>	<u>Leakage Rate</u>	<u>Area</u>	<u>Volume</u>
1	0.5 foot/yr	3,360,000 ft ²	1,680,000 ft ³ /yr
2	1.0 foot/yr	3,360,000 ft ²	3,360,000 ft ³ /yr
3	1.5 foot/yr	3,360,000 ft ²	5,040,000 ft ³ /yr
4	2.0 foot/yr	3,360,000 ft ²	6,720,000 ft ³ /yr

Water Budget Calculations

<u>Case</u>	<u>Total Inflow</u> <u>(Q1+Q2+Q3)</u>	<u>Total Outflow</u> <u>(Q4+Q5)</u>	<u>Percent Error</u>
1	2,943,000	1,623,000	+29
2	4,218,000	3,815,000	+5.0
3	5,493,000	5,495,000	0.0
4	6,768,000	7,175,000	-3.0

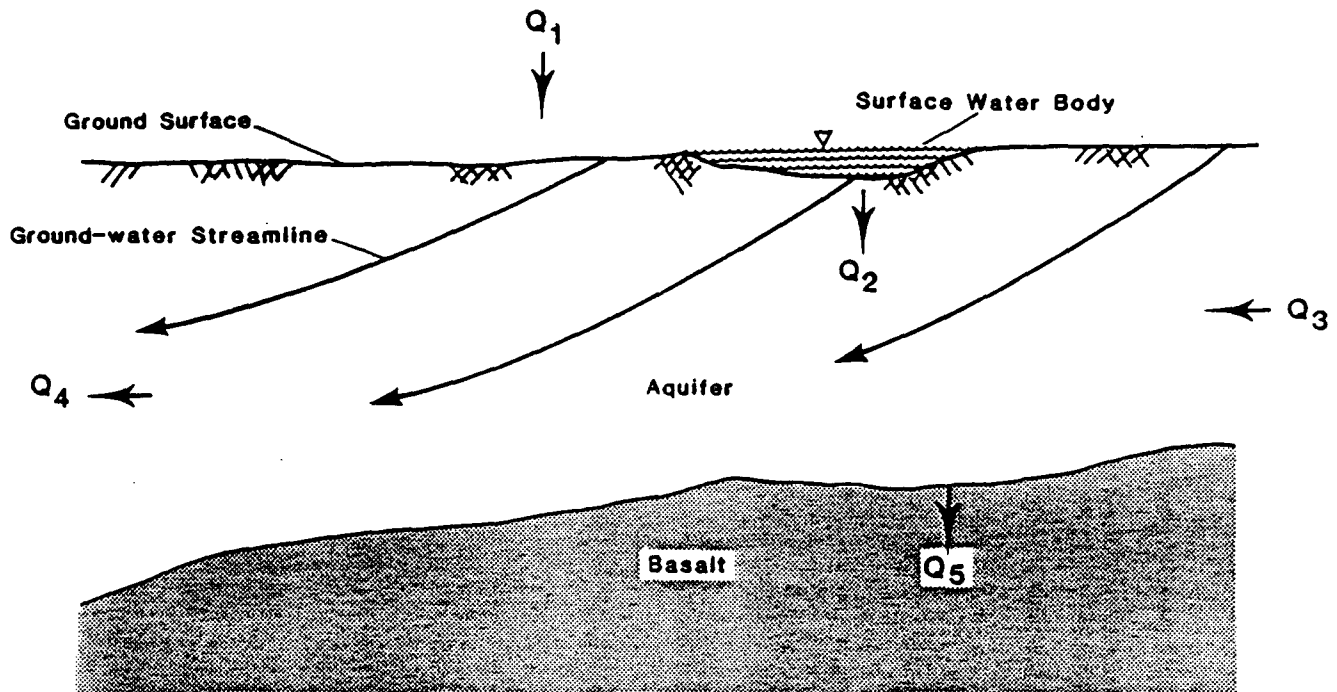
Summary

The hydraulic parameters identified in this analysis are:

- Infiltration rate from precipitation;
- Infiltration rate from the surface water bodies;
- Depth of water in the surface water bodies;
- Vertical and horizontal hydraulic conductivities;
- Saturated thickness, and
- Horizontal hydraulic gradients.

The hydraulic parameters that significantly control the ground-water flow system in the vicinity of the Gould site are infiltration by precipitation, infiltration from the surface water bodies, lateral inflow and outflow, and leakage into the underlying basalts. Based upon the data and assumptions presented in this water budget analysis, the infiltration from precipitation and leakage into the basalts were not as well defined as the other components of ground-water recharge and discharge. The sensitivity of infiltration from precipitation and leakage into the basalts were tested by varying the assumed rates while keeping the other components of recharge and discharge constant. The lowest percent error was zero percent for an infiltration rate of 15 in/yr and a leakage rate of 1.5 ft/yr.

The quantity of recharge is clearly dominated by rainfall infiltration and the quantity of discharge is clearly dominated by leakage to the basalt.



$$Q_1 + Q_2 + Q_3 = Q_4 + Q_5$$

Q_1 = Infiltration Rate from Precipitation

Q_2 = Infiltration Rate from the Surface Water Body

Q_3 = Lateral Inflow Rate

Q_4 = Lateral Outflow Rate

Q_5 = Leakage Rate into the Basalt

11831-034

NL IND, INC./GOULD, INC. REMEDIAL INVESTIGATION	
CONCEPTUAL MODEL OF WATER BUDGET ANALYSIS	
FIG. 4.4-20	DAMES & MOOR

4.5 CONTAMINANT MIGRATION

4.5.1 Contaminants

The primary wastes produced as a result of operations on the Gould site are shredded battery casings, battery electrolyte (sulfuric acid) and blast furnace matte. The primary contaminant of concern from these sources is lead; arsenic, zinc, chromium, cadmium, and sulfate are potential secondary contaminants.

Adjacent industries produced various other types of contaminants that were disposed of on or near the site. These additional wastes include hydrated lime, alkaline acetylene waste, shredded automobile interiors, herbicides and other organics (phenols), demolition debris, metallic wastes, steel scrap and zirconium casting sand. This study is focused on the wastes associated with the Gould operations.

4.5.2 Soil Contaminant Delineation

4.5.2.1 Fill

Distribution of metals (lead, arsenic, cadmium, chromium, iron, and zinc) sulfate, pH and cation exchange capacity were evaluated by analysis of 47 subsurface samples of the fill. Samples were collected from four soil borings (B-5, B-6, B-8 and B-10) and from five monitoring well locations (W-3, W-7, W-11, W-15 and W-16). Seven of the subsurface samples were duplicates; thus a total of 40 subsurface locations within the fill were sampled and analyzed. Boring and well locations are shown on Figure 4.5-1. In addition, 50 samples of the top few inches of the fill were sampled and analyzed to evaluate the surficial distribution of potential contamination. Surface soil sample locations are shown on Figure 4.5-2. Six of the surface samples were duplicates, thus a total of 44 surface locations were sampled and analyzed. (Refer to Appendices A, B, and C, respectively, for a discussion of soil sampling procedures, QA/QC protocol, and results of the laboratory analyses.)

All surface and subsurface samples of the fill were analyzed for lead and pH. Twenty-four of the subsurface samples were analyzed for

arsenic and hexavalent chromium, while 28 were analyzed for cadmium, chromium, zinc, iron, sulfate and cation exchange capacity. Eleven of the surface samples were analyzed for hexavalent chromium, while 14 were analyzed for arsenic, cadmium, chromium, zinc, iron, sulfate, and cation exchange capacity. Results of the subsurface analyses of the fill are summarized on Table 4.5-1. Results of the analyses of the surface samples of the fill are shown on Table 4.5-2. Surface distribution of the various analytes is shown on Figures 4.5-3 through 4.5-10.

All locations in the fill where subsurface samples were analyzed have at least one sample which shows some evidence of metal or sulfate contamination. Subsurface distribution of lead concentrations is shown on Figures D6-1 and D6-12 (Appendix D6) in the form of lead concentration versus distance from the fill/alluvium contact. Distributions versus distance from the contact are shown for arsenic, cadmium, chromium, zinc, iron, sulfate and pH on Figures D6-13 through D6-20.

The fill at well W-7 has the highest concentrations of lead found in any of the soil samples taken for this study. This is to be expected because the well is in the area where battery casing fragments were buried off the Gould property (see Section 3.2.3). Indeed, the analyses of the two uppermost samples from W-7 (W-7-1 and W-7-2) are probably more representative of the casing fragments than they are of the fill (lead concentrations of 2.6 and 6.7 percent).

The pattern of lead occurrence in surface soils (Figure 4.5-4) corresponds to areas where battery casing fragments were buried or processed, as shown on Figure 3.2-3. Although few samples of surface soil from the fill were evaluated for other metals, the distribution of high metal concentration occurrences is generally similar to that for lead (Figures 4.5-5 to 4.5-10; concentration in surface soils for arsenic, cadmium, chromium, zinc, iron and sulfate, respectively).

There are two exceptions to this pattern. One is the chromium concentration of 170 ppm in SS-32, located in the southeastern corner of the ESCO property (Figure 4.5-7). This sample was taken from the clay cap emplaced over the fill on the ESCO property. This chromium

concentration occurrence may have been introduced during the emplacement of the clay cap. The clay cap may have contained metal chips from the pug mill used to process the clay.

The second exception is the three samples from Liquid Air and Schnitzer property (S-15, S-17 and S-19) that have chromium concentrations from 120 to 390 ppm. These, and other samples from that area (S-16 and S-18) also have high lead and zinc concentrations. The sources of these concentrations are unknown.

In summary, variable concentrations of metals are present in much of the fill. The distribution of concentrations appears to be directly related to the known site history and to the various types of fills placed in Doane Lake. No obvious pattern of contaminant migration within the fills is apparent from the data, however, there appears to be a rough relationship between distance from the lakes or the battery fragments and lead concentrations. Plots of lead concentration versus the distance of the sample from the East Doane Lake remnant or the buried casing fragments (whichever is closer) are presented in Figure 4.5-11. This figure shows that concentrations decrease at increasing distances from the identified sources.

4.5.2.2 Doane Lake and Willamette River Sediments

Sediment samples collected from the east remnant contained total lead concentrations ranging from 160 mg/kg (parts per million) to 12,000 mg/kg. Total lead concentration was consistently highest at station SD-02 (Figure 4.5-12) in all sampling rounds, ranging from 3,900 mg/kg to 12,000 mg/kg (Appendix C, Table C-3). Other stations in the east remnant with relatively high total lead concentrations included SD-01 (4,100 mg/kg in round 3), SD-03 (2,600 mg/kg in round 3), and SD-11 (4,900 mg/kg in round 3). EP Toxicity tests for lead at station SD-02 showed a concentration of 28 mg/l leachable lead. No other stations in the east remnant had leachable lead concentrations greater than the EP Toxicity limit of 5 mg/l for hazardous waste designation.

Highest total arsenic concentrations were measured at SD-01 (99 mg/kg) and SD-11 (98 and 160 mg/kg; Appendix C, Table C-3). Total

cadmium was highest at station SD-02 (36 mg/kg). None of these metals exceeded EP Toxicity limits.

West Doane Lake remnant sediment samples collected in 1986 and February 1987 had relatively uniform total lead concentrations at the southern end and middle portion of the remnant (1,500 and 1,000 mg/kg lead, respectively; Appendix C, Table C-3). The concentrations in samples from the northern end of the west remnant were much lower, ranging from 240 to 780 mg/kg lead. Total arsenic concentrations ranged from 20 to 76 mg/kg, total cadmium from 2.2 to 6.5 mg/kg, total chromium from 110 to 2,200 mg/kg, and total zinc from 440 to 2,000 mg/kg. EP Toxicity test results for lead, arsenic, cadmium, and chromium in west remnant sediments were all below hazardous waste limits.

Sediments collected in the Willamette River during August 1986 and February 1987 had generally low metals concentrations. Total lead concentrations ranged from 26 to 56 mg/kg (Appendix C, Table C-3). Other metals concentrations included total arsenic at 5.7 to 6.2 mg/kg, total chromium at 9 to 26 mg/kg, and total zinc at 72 to 82 mg/kg. Cadmium and hexavalent chromium concentrations were near or below the detection limits.

4.5.2.3 Alluvium

Distribution of metals (lead, arsenic, cadmium, chromium, zinc and iron), sulfate, pH, and cation exchange capacity in the alluvium were evaluated by analysis of 53 samples of the alluvium. The samples were collected from soil borings (B-5, B-6, B-8, and B-10) and from five of the monitoring well borings (W-6, W-7, W-11, W-15, and W-16), as shown on Figure 4.5-1. All samples were analyzed for lead and pH. Eight of the 53 samples were selected at random for analyses for the remaining analytes. Table 4.5-3 summarizes the results of these analyses for samples of the alluvium. To facilitate evaluation of the potential migration of contamination of lead and other metals into the alluvium from the fill, the depth of the samples below the top of the alluvium is also shown on Table 4.5-3. Depth of the sample below ground surface, coordinates of the well/boring, and the sample designation are also shown.

TABLE 4.5-1
SUMMARY OF CHEMICAL ANALYSES
SUBSURFACE SAMPLES OF FILL

SAMPLE LOCATION	EAST CORD	NORTH CORD	SAMPLE DESIG.	DIST OF SAMP FR. TOP OF ALLUVIUM	GEOLOGIC UNIT	SUMMARY OF LABORATORY RESULTS (1)										CATION EXCH CAP	TOTAL SOLIDS
						Pb	Pb	As	Cd	Cr	MEQ Cr	Zn	Fe	SO4			
B-10	10109.8	9256.2	B-10-6	1.0	FILL	10.3	140	15.0	1.10	190	0.5	170	23000	130	7.10	81.5	
B-10	10109.8	9256.2	B-10-5	5.7	FILL	10.4	17	2.5	0.70	1200	0.5	10	17000	150	3.60	89.6	
B-10	10109.8	9256.2	B-10-4	7.5	FILL	9.4	33	3.5	0.50	1000	0.5	71	64000	25	5.00	91.5	
B-10	10109.8	9256.2	B-10-3	11.0	FILL	10.1	60									70.2	
B-10	10109.8	9256.2	B-10-2	16.0	FILL	9.0	240	5.0	2.40	770	0.5	210	44000	70	4.00	91.2	
B-10	10109.8	9256.2	B-10-1	21.5	FILL	8.0	10	0.9	0.70	7	0.5	6	10000	40	2.20	91.2	
B-5	10652.7	9196.8	B-05-4	1.5	FILL	10.0	190									74.2	
B-5	10652.7	9196.8	B-05-3	6.5	FILL	11.0	210									79.3	
B-5	10652.7	9196.8	B-05-2	11.5	FILL	11.0	90	14.0	0.60	200	1.0	89	20000	100	0.20	83.1	
B-5	10652.7	9196.8	B-05-1	15.5	FILL	11.0	110	14.0	0.70	290	1.0	130	31000	160	7.60	82.3	
B-5	10652.7	9196.8	B-05-1-dup	15.5	FILL	11.0	120									82.7	
B-6	10530.4	9353.7	B-06-4	2.0	FILL	7.7	74									81.6	
B-6	10530.4	9353.7	B-06-3	7.0	FILL	7.7	16									75.6	
B-6	10530.4	9353.7	B-06-2	12.0	FILL	9.2	75	13.0	0.60	57	1.0	93	26000	140	10.50	82.4	
B-6	10530.4	9353.7	B-06-2-dup	12.0	FILL	8.0	56	13.0	0.60	27	1.0	90	26000	160	11.50	81.8	
B-6	10530.4	9353.7	B-06-1	17.0	FILL	10.0	42	8.3	0.50	23	1.0	75	25000	220	10.00	80.9	
B-0	10116.6	9552.5	B-00-7	0.5	FILL	6.2	41	5.3	0.70	16	1.0	130	26000	100	19.30	65.4	
B-0	10116.6	9552.5	B-00-6	2.5	FILL	11.0	30	3.0	0.50	420	1.0	36	27000	150	3.00	86.6	
B-0	10116.6	9552.5	B-00-5	7.5	FILL	11.0	87	1.4	0.50	740	1.0	81	61000	190	6.70	87.3	
B-0	10116.6	9552.5	B-00-4	12.5	FILL	11.0	90	4.0	0.70	250	1.0	70	26000	46	4.00	87.0	
B-0	10116.6	9552.5	B-00-3	17.5	FILL	10.0	21	3.1	0.50	240	1.0	16	85000	20	1.40	86.4	
B-0	10116.6	9552.5	B-00-2	22.5	FILL	10.0	96	3.1	0.70	200	1.0	130	31000	40	0.90	90.1	
B-0	10116.6	9552.5	B-00-2-dup	22.5	FILL	11.0	140									89.7	
B-0	10116.6	9552.5	B-00-1	27.5	FILL	8.4	46	2.3	0.50	41	1.0	38	21000	77	9.70	86.7	
W-110	9967.4	9967.5	W-110-5	0.0	FILL	7.9	32									70.0	
W-110	9967.4	9967.5	W-110-4	5.0	FILL	9.5	120	73.0	0.60	200	1.0	92	24000	26	11.40	77.4	
W-110	9967.4	9967.5	W-110-3	10.0	FILL	12.0	70	3.9	0.50	100	1.0	47	130000	31	11.70	86.0	
W-110	9967.4	9967.5	W-110-3-dup	10.0	FILL	10.0	21	2.7	0.50	260	0.5	54	35000	110	12.00	80.6	
W-110	9967.4	9967.5	W-110-2	15.0	FILL	11.0	40	2.4	0.50	440	1.0	59	92000	37	7.30	86.0	
W-110	9967.4	9967.5	W-110-1	20.0	FILL	11.0	17	0.7	0.50	450	1.0	10	29000	27	2.20	89.4	
W-150	10683.3	0656.6	W-150-2	1.0	FILL	12.7	2300	07.0	13.00	24	0.5	210	6600	50	3.50	55.7	
W-150	10683.3	0656.6	W-150-4	3.5	FILL	11.9	120		0.50	410		110	44000	12	9.20	82.4	
W-150	10683.3	0656.6	W-150-4-dup	3.5	FILL	10.9	150									77.1	
W-150	10683.3	0656.6	W-150-1	5.5	FILL	11.4	290	3.7	1.50	1100	0.5	1000	140000	200		71.0	
W-150	10683.3	0656.6	W-150-1-dup	5.5	FILL	11.4											
W-155	10675.3	0664.5	W-155-2	1.2	FILL	10.6	340									70.2	
W-155	10675.3	0664.5	W-155-1	11.5	FILL	8.0	120									83.0	
W-160	11001.7	0863.3	W-160-3	0.5	FILL	11.1	23	4.3	1.30	19		55	19000	350	10.00	83.0	
W-160	11001.7	0863.3	W-160-1	5.5	FILL	11.4	110									75.4	
W-302	10441.9	9472.4	W-30-3	1.0	FILL	7.0	330		1.90	74		220	31000	6100	26.10	50.2	
W-302	10441.9	9472.4	W-30-2	6.0	FILL	9.2	27		0.50	36		64	25000	310	9.20	73.5	
W-302	10441.9	9472.4	W-30-2-dup	6.0	FILL	9.4	26									81.0	
W-302	10441.9	9472.4	W-30-1	11.0	FILL	8.0	56									83.0	
W-75	10006.9	9141.6	W-75-4	4.0	FILL	4.5	820									81.7	
W-75	10006.9	9141.6	W-75-3	5.0	FILL	5.0	620									70.7	
W-75	10006.9	9141.6	W-75-2	14.0	FILL	6.0	26000									87.3	
W-75	10006.9	9141.6	W-75-1	19.0	FILL	5.9	67000									89.2	

NOTES:

1) Value for analyte on left is concentration in mg/kg (ppm).

2) Distance from top of alluvium refers to the distance above or below the fill/alluvium contact.

ALLUVIUM AVERAGE	6.9	20.9	4.7	0.9	23.0	0.0	50.6	24750.0	71.9	12.0
ALLUVIUM MAXIMUM	10.9	85.0	6.0	1.6	39.0	1.0	70.0	34000.0	160.0	26.9
ALLUVIUM STD DEV	1.6	12.6	1.0	0.4	7.4	0.3	10.6	5471.5	39.5	6.7
NUMBER OF SAMPLES	53.0	53.0	5.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0

TABLE 4.5-2

SHEET 1 OF 2

SUMMARY OF CHEMICAL ANALYSES
SURFACE SOILS AND BACKGROUND (1)

SAMPLE	EAST COORD	NORTH COORD	GEOLOGIC UNIT	pH	Pb	As	Cd	Cr	Hex Cr	Zn	Fe	Sb	CE Cap	TOTAL SOLIDS
S-01	10167	0472	SURFACE	5	530									93.6
S-01-dup	10167	0472	SURFACE	5.2	480									93.6
S-02	10059	0605	SURFACE	5.2	1700									93.1
S-03	9972	0670	SURFACE	0	3300	19	3.4	15	0.5	10000	27000	43	6.0	94
S-04	10124	0733	SURFACE	0	7900									94.1
S-05	10190	0840	SURFACE	7.3	10000									80
S-06	10210	0720	SURFACE	6.6	1500									93.5
S-07	10234	0800	SURFACE	6.6	1100									93.1
S-09	10250	0941	SURFACE	7.2	20000	63	12	16	0.5	320	34000	500	6.5	93
S-09-dup2	10250	0941	SURFACE		19000	52	11	16	0.5	320	34000	550	6.1	93
S-10R	10653	9197	SURFACE	0.2	130									77.1
S-11R	10530	9354	SURFACE	0.5	27									92.9
S-12	10360	0755	SURFACE	4.7	1500	15	0.6	15	0.5	89	24000	110	4.3	92.4
S-13	10313	0680	SURFACE	5.7	1400									92.4
S-14	10223	0517	SURFACE	5.9	120									91.2
S-20	9790	0740	SURFACE	7.4	260									92.5
S-21	9605	0760	SURFACE	7.5	160	47	0.8	10	0.5	130	33000	14	13	91.6
S-23	9815	0945	SURFACE	7.6	640	7.4	1	16	0.5	170	29000	250	10.6	92
S-24	9642	9064	SURFACE	0.2	750									92.1
S-25	9505	9165	SURFACE	7.6	520									87.5
S-26	9955	0945	SURFACE	0.7	1200	7.1	0.5	15	0.5	100	32000	410	9.2	92.4
S-27	9955	9123	SURFACE	7.4	590	5.5	1.2	10	0.5	300	12000	9600	7.2	90
S-27-dup	9955	9123	SURFACE		990	2.6	1.7	11	0.5	430	14000	9700	7.2	90.4
S-28	9705	9255	SURFACE	9.2	17000									91.7
S-29	9600	9325	SURFACE	7.9	7800									93.3
S-30	9566	9390	SURFACE	0	220									91.2
S-30-dup	9566	9390	SURFACE	0.1	250									91.4
S-31	10110	9256	SURFACE	0.4	60									92.1
S-32	9979	9407	SURFACE	0.2	23	3.0	0.5	170	0.5	55	31000	36	11.2	92
S-33	9046	9555	SURFACE	0.3	22									92.2
S-34	9709	9699	SURFACE	0.2	17									91
S-35	9590	9020	SURFACE	7.4	15	4.0	0.5	10	0.5	51	24000	120	13.0	82.6
S-36	10243	9390	SURFACE	7.0	10									89.4
S-37	10117	9552	SURFACE	0	16									89.7
S-38	9904	9700	SURFACE	0.6	19									89.3
S-39	9053	9045	SURFACE	7.6	19									87.0
S-40	9719	9993	SURFACE	6.9	10									90.4
S-41	10353	9511	SURFACE	7.9	19									91.5
S-42	10227	9664	SURFACE	9.2	21									86.4
S-42-dup	10227	9664	SURFACE	9.3	16									91.2
S-43	10095	9012	SURFACE	0.3	14									89.9
S-44	9955	9960	SURFACE	0.6	10									83.3
S-45	9025	10099	SURFACE	0.4	20									91.6
S-15	11004	0401	SURFACE	0.4	230	7.0	2.5	390		700	31000	34	7.7	85.6
S-16	11112	0507	SURFACE	0.4	120	16	1.0	170		160	37000	21	14	86.7
S-17	10969	0640	SURFACE	0.6	95									80.2
S-17-dup	10969	0640	SURFACE	0.6	100									72.9
S-18	9726	0700	SURFACE	0.4	110									85.3
S-19	9763	0894	SURFACE	7.9	140	6.5		120		140	39000	20	16	87.5
S-22	9500	0900	SURFACE	6.0	66									88

TABLE 4.5-2
SUMMARY OF CHEMICAL ANALYSES
SURFACE SOILS AND BACKGROUND (1)

SAMPLE	EAST COORD	NORTH COORD	GEOLOGIC UNIT	pH	Pb	As	Cd	Cr	Hex Cr	Zn	Fe	S04	CE Cap	TOTAL SOLIDS
S-56	(	)	BACKGROUND	7.1	85									77.4
S-57	(	refer	BACKGROUND	6.3	45									81.6
S-58	(	to	BACKGROUND	)	44									79.1
S-59	Fig. 4.5-13		BACKGROUND	5.9	34									78.3
S-60	(	)	BACKGROUND	5.6	15									85
BACKGROUND AVERAGE				6.4	44.6									
BACKGROUND MAXIMUM				7.1	85.0									
BACKGROUND STD DEV				0.6	22.9									
NUMBER SAMPLES				5.0	5.0									
ALLUVIUM AVERAGE				6.9	20.9	4.7	0.9	23.0	0.0	58.6	24750.0	71.9	12.0	
ALLUVIUM MAXIMUM				10.9	85.0	6.0	1.6	39.0	1.0	78.8	34000.0	160.0	26.9	
ALLUVIUM STD DEV				1.6	12.6	1.0	0.4	7.4	0.3	10.6	5471.5	39.5	6.7	
NUMBER OF SAMPLES				53.0	53.0	5.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	

NOTES

- 1) Value for analyte on left is concentration in mg/kg (ppm).
- 2) Refer to Figure 4.5-2 for surface soil locations.
- 3) Refer to Figure 4.5-13 for background sample locations.

TABLE 4.5-5

GROUND WATER - ROUND 1 (Aug - Sept, 1986), ROUND 2 (Dec, 1986 - Jan, 1987),
AND ROUND 3 (Feb, 1987) ANALYSIS RESULTS

S I N	ROUND	LAB#	SAMPLED	DATE	pH	pH	Tot. Ph	T.B. Ph	Dis. Ph	Dis. As	Dis. Cd	Dis. Cr	Dis. Zn	Dis. Fe	Dis. SO4	TOC	Dis. Cl	Dis. NO3(N)	DT P04(P)	Dis. Ca	Dis. K	Dis. Mg	Dis. Na	EC	ALK.	HAZ.	
SAMPLE #					field	lab	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	umho/cm	mg/L	mg/L		
BASALT AQUIFER																											
M-060	1	98644	- 1	09/04/86	7.2	7.4	--	--	0.02	0.005U	0.002U	0.005U	0.002U	0.14 B	52	--	310	0.05U	0.270	42.0	0.00	20.00	380	1800	500 J	230	
M-060	2	1298	- 14	12/15/86	7.3	7.3	0.01U	0.01U	0.01U	0.005U	0.002U	0.005U	0.003	0.01U	49	36.00	340	0.05U	0.180	37.0	7.50	22.00	310	1700	440	220	
M-060	3	2411	- 27	02/22/87	7.1	6.7	0.01	0.01U	0.01U	0.005U	0.002U	0.005U	0.004	0.04 B	51	9.40	270	0.05U	0.160	55.0	7.20	21.00	250	1400	430	220	
M-060-dup	1	98644	- 2	09/04/86	--	7.5	--	--	0.02	0.005U	0.002U	0.005U	0.002U	0.32 B	45	--	270	0.05U	0.260	42.0	8.20	27.00	370	1700	480 J	210	
M-110	1	98634	- 1	09/03/86	7.0	7.0	--	--	0.02	0.005U	0.002U	0.004	0.005	6.50	34	--	500	0.05U	0.262	200.0	7.40	74.00	18	1900	170 J	700	
M-110	2	1298	- 17	12/16/86	7.8	7.2	0.01	0.01U	0.01U	0.005U	0.002U	0.005U	0.004	0.20 B	32	14.00	430	0.05U	0.008	190.0	6.80	45.00	39	1800	160	750	
M-110	3	2538	- 21	02/24/87	6.8	6.5	0.01	0.01U	0.01U	0.005U	0.002U	0.005U	0.044	0.59	28	5.10	380	0.05U	0.005U	190.0	6.50	41.00	40	1700	170	820	
ALUMINUM AQUIFER																											
PP-08	2	1298	- 5/	12/30/86	6.6	6.7	0.02	0.02	0.02	0.035	0.002U	0.005U	0.019	42.00	590	80.00	1400	0.05U	0.430	390.0	1.90	110.00	390	4000	200	1400	
PP-08	3	2411	- 21	02/21/87	5.9	6.5	0.05	0.05	0.01	0.048	0.002U	0.005U	0.013	8.30	470	40.00	1300	0.05U	0.068	350.0	2.50	93.00	820	5400	580	1300	
PP-11	2	1298	- 51	12/29/86	6.3	6.3	1.00	0.02	0.01U	0.005U	0.002U	0.005U	0.024	38.00	20	48.00	190	0.05U	0.030	47.0	4.80	21.00	63	1100	160	720	
PP-11	3	2538	- 41	02/25/87	6.4	6.2	0.38	0.37	0.01	0.005U	0.002U	0.005U	0.079	8.30	17	10.00	190	0.05U	0.034	57.0	4.70	20.00	84	970	180	260	
RPV-40	1	98825	- 10	09/18/86	6.4	6.6	--	--	0.01	0.005U	0.002U	0.005U	0.004	0.30 B	1100	--	400 J	0.42	0.005U	310.0	8.20	150.00	160	5100	390	2200	
RPV-40	2	1298	- 12	12/14/86	6.5	6.4	0.01U	0.01	0.01U	0.005U	0.002U	0.005U	0.013	0.01U	1500	410.00	470	0.05U	0.013	410.0	7.90	210.00	91	3900	400	2300	
RPV-40	3	2538	- 50	02/26/87	6.1	6.4	0.01U	0.01U	0.01	0.005U	0.002U	0.005U	0.270	22.00	1900	300.00	430	0.07	0.038	460.0	8.00	200.00	120	3500	370	2100	
M-010	1	98587	- 1	03/28/86	6.4	6.5	--	--	0.01U	0.005U	0.002U	0.005U	0.014	3.30	15	--	40 J	0.40	0.093	33.0	2.60	21.00	1U	440	130 J	170	
M-010	2	1298	- 2	12/10/86	6.1	6.4	0.01U	0.01U	0.01U	0.005U	0.002U	0.005U	0.015	0.01U	17	0.30	40	0.43	0.130	29.0	3.70	19.00	13	440	120	180	
M-010	3	2411	- 4	02/17/87	6.3	5.8	0.01U	0.01U	0.01U	0.005U	0.002U	0.005U	0.010	0.08 B	20	2.20	43	0.39	0.110	38.0	3.80	18.00	13	380	110	180	
M-020	1	98587	- 2	08/28/86	6.0	5.8	--	--	0.21	0.010	0.002U	0.010	6.500	570.00	14000	--	200 J	31.00	0.150	220.0	23.00	2000.00	300	12000	1UJ	4400	
M-020	2	1298	- 40	12/19/86	--	6.0	1.70	1.80	0.03	0.130	0.002U	0.014	5.000	4300.00	14000	16.00	130	14.00	0.005U	390.0	19.00	680.00	200	11000	1U	4500	
M-020	3	2538	- 47	02/25/87	5.7	4.3	0.49	0.48	0.03	0.140	0.002U	0.008	5.900	3200.00	17000	8.70	250	38.00	0.180	440.0	27.00	930.00	280	15000	60	6000	
M-020-dup	3	2538	- 43	02/26/87	--	4.2	0.50	0.49	0.05	0.290	0.002U	0.009	4.900	3900.00	18000	7.90	240	0.27	0.200	460.0	27.00	950.00	280	15000	77	6300	
M-030	1	98587	- 3	08/27/86	6.4	6.2	--	--	0.03	0.021	0.002U	0.013	0.070	420.00	3400	--	2000 J	1.60	0.570	460.0	18.00	430.00	1500	9300	160 J	3000	
M-030	2	1298	- 22	12/17/86	6.1	6.1	0.02	0.02	0.03	0.005	0.002U	0.005U	0.032	2500.00	4900	38.00	1800	0.22	0.019	780.0	14.00	420.00	630	12000	10	3600	
M-030	3	2411	- 12	02/19/87	6.2	6.0	0.02	0.02	0.02	0.018	0.002U	0.005U	0.016	720.00	3300	6.90	2100	0.15	0.024	670.0	16.00	290.00	1000	10000	98	2800	
M-030(2)	2	1298	- 49	12/21/86	7.0	6.9	0.01U	0.01U	0.01U	0.010	0.002U	0.005U	0.018	0.71 B	4	10.00	4	0.05U	0.220	39.0	5.30	12.00	22	440	200	180	
M-030(2)	3	2411	- 25	02/21/87	6.9	7.7	0.05	0.04	0.01	0.030	0.002U	0.005U	0.039	0.83 B	9	4.10	4	0.05U	0.180	47.0	5.00	10.00	28	480	210	170	
M-040	1	98587	- 4	08/27/86	6.7	6.5	--	--	0.03	0.031	0.002U	0.005U	0.160	460.00	96	--	1900 J	0.030	0.100	480.0	12.00	290.00	180	5800	170 J	2200	
M-040	2	1298	- 4	12/11/86	6.9	6.7	0.02	0.02	0.01U	0.010	0.002U	0.005U	0.015	290.00	18	53.00	1500	0.05U	0.014	350.0	11.00	190.00	100	5700	110	2100	
M-040	3	2411	- 22	02/21/87	6.3	6.5	0.02	0.02	0.01	0.018	0.002U	0.005U	0.007	30.00	1U	9.70	1700	0.05U	0.013	350.0	11.00	180.00	120	4900	320	2000	
M-040-dup	3	2411	- 23	02/21/87	--	6.5	0.03	0.02	0.01	0.019	0.002U	0.005U	0.005	30.00	18	0.70	1700	0.05U	0.020	360.0	11.00	180.00	120	5000	210	2000	
M-060	1	98644	- 3	09/04/86	6.8	6.9	--	--	0.01	0.005	0.002U	0.017	0.004 B	6.70	17	--	130	0.05U	0.330	100.0	4.10	49.00	1U	1700	390 J	530	
M-060	2	1298	- 15	12/15/86	6.8	7.1	0.01U	0.01U	0.01U	0.004	0.002U	0.005U	0.002	0.62 B	22	30.00	84	0.05U	0.022	77.0	4.00	38.00	22	800	300	390	
M-060	3	2411	- 28	02/22/87	6.5	6.6	0.04	0.01U	0.01U	0.014	0.002U	0.005U	0.011	9.70	14	13.00	42	0.05U	0.010	49.0	3.80	33.00	18	740	310	340	
M-065	1	98644	- 4	09/04/86	6.8	6.8	--	--	0.12	0.011	0.002U	0.005U	0.091	7.90	4	--	320	0.19	0.140	170.0	6.20	100.00	170	2100	630 J	700	
M-065	2	1298	- 6	12/12/86	6.6	6.9	0.02	0.02	0.01U	0.005U	0.002U	0.005U	0.014	0.01U	9	120.00	1000	0.05U	0.004	170.0	7.60	70.00	490	4300	720	700	
M-065	3	2411	- 29	02/22/87	6.2	6.5	0.05	0.04	0.02	0.021	0.002U	0.005U	0.015	4.40	31	24.00	1700	0.05U	0.037	250.0	7.60	69.00	970	5200	780	940	
M-065-dup	3	2411	- 30	02/22/87	--	6.5	0.05	0.04	0.02	0.021	0.002U	0.005U	0.015	4.40	27	19.00	1500	0.05	0.027	260.0	7.80	67.00	940	5500	760	960	
M-070	1	98825	- 1	09/15/86	3.8	3.4	--	--	0.17	0.012	0.002U	0.170	11.000	2500.00	28000	--	410 J	34.00	0.012	260.0	49.00	250.00	450	18000	1U	4200	
M-070	2	1298	- 38	12/18/86	3.7	3.9	0.16	0.15	0.12	0.017	0.005	0.200	13.000	4500.00	31000	21.00	440	12.00	6.100	220.0	50.00	1000.00	340	2100	1U	5100	
M-070	3	2538	- 47	02/24/87	3.7	3.9	0.01	0.01	0.07	0.019	0.003	0.140	8.300	1800.00 B	24000	15.00	440	0.31	0.040	470.0	45.00	940.00	480	18000	1U		

TABLE 4.5-5

GROUND WATER - ROUN. 1 (Aug - Sept, 1986), ROUN. 2 (Dec, 1986 - Jan, 1987),
AND ROUN. 3 (Feb, 1987) ANALYSIS RESULTS

[illegible][illegible]

U (following a number of other similar cases) was not a defendant in the case.

קובץ: תולדות ארץ ישראל ויהודה - חלק א' - חלק 1

0: following a number indicates plant concentration within the sample result. See Appendix B section 4.0 for explanation.

11: following a number indices estimated (unintentional). See Appendix B Section 4.0 for explanation.

TABLE 4.5-3
SUMMARY OF CHEMICAL ANALYSES
SUBSURFACE SAMPLES OF ALLUVIUM

SAMPLE LOCATION	EAST COORD	NORTH COORD	SAMPLE DESIG.	DIST OF SAMP FR. TOP OF ALLUVIUM UNIT	GEOLOGIC UNIT	SUMMARY OF LABORATORY RESULTS (1)										CATION EXCH CAP	TOTAL SOLIDS
						Pb	Pb	As	Cd	Cr	HEX Cr	Zn	Fe	Sb			
B-10	10109.0	9256.2	B-10-0	-9.5	ALLUVIUM	4.0	15									73	
B-10	10109.0	9256.2	B-10-0	-4.2	ALLUVIUM	4.5	13									76	
B-10	10109.0	9256.2	B-10-7	-2.7	ALLUVIUM	8.9	43									80	
B-5	10632.7	9196.8	B-05-6	-3.5	ALLUVIUM	5.0	16									62	
B-5	10632.7	9196.8	B-05-5	-1.0	ALLUVIUM	9.6	62									77	
B-6	10530.4	9353.7	B-6-6	-0.0	ALLUVIUM	5.2	17									67	
B-6	10530.4	9353.7	B-06-5	-1.0	ALLUVIUM	5.7	29									64	
B-0	10009.0	9552.6	M-120-20	-47.0	ALLUVIUM	6.6	10									71	
B-0	10009.0	9552.6	M-120-25	-37.0	ALLUVIUM	6.3	15									63	
B-0	10009.0	9552.6	M-120-20	-27.0	ALLUVIUM	5.0	15									67	
B-0	10009.0	9552.6	M-120-16	-17.0	ALLUVIUM	6.0	14									66	
B-0	10009.0	9552.6	M-120-12	-7.0	ALLUVIUM	6.6	15									62	
B-0	10116.6	9552.5	B-00-0	-1.5	ALLUVIUM	5.7	16	3.3	0.50	15	1.0	64	29000	50	26.90	60	
M-110	9967.4	9967.5	M-110-12	-75.0	ALLUVIUM	7.8	17									71	
M-110	9967.4	9967.5	M-110-11	-65.0	ALLUVIUM	7.2	17									73	
M-110	9967.4	9967.5	M-110-10	-55.0	ALLUVIUM	7.2	15									71	
M-110	9967.4	9967.5	M-110-9	-45.0	ALLUVIUM	7.4	17									75	
M-110	9967.4	9967.5	M-110-8	-35.0	ALLUVIUM	7.9	22									70	
M-110	9967.4	9967.5	M-110-70	-25.0	ALLUVIUM	6.5	13									72	
M-110	9967.4	9967.5	M-110-7	-10.0	ALLUVIUM	5.0	24									56	
M-110	9967.4	9967.5	M-110-6	-5.0	ALLUVIUM	7.0	20									57	
M-150	10603.3	0656.6	M-150-12	-40.5	ALLUVIUM	8.0	12									73	
M-150	10603.3	0656.6	M-150-11	-30.0	ALLUVIUM	5.6	21									74	
M-150	10603.3	0656.6	M-150-10	-20.0	ALLUVIUM	3.6	36									79	
M-150	10603.3	0656.6	M-150-9	-24.0	ALLUVIUM	4.3	10									82	
M-150	10603.3	0656.6	M-150-8	-10.5	ALLUVIUM	3.6	10									79	
M-150	10603.3	0656.6	M-150-7	-13.0	ALLUVIUM	9.4	26	4.0	0.70	39		53	22000	70	7.70	80	
M-150	10603.3	0656.6	M-150-6	-9.0	ALLUVIUM	9.7	16									75	
M-150	10603.3	0656.6	M-150-5	-2.0	ALLUVIUM	7.0	23	3.9	1.60	20		47	10000	64	7.50	78	
M-150	10603.3	0656.6	M-150-3	-0.6	ALLUVIUM	10.9	17	6.0	0.60	15	0.5	47	23000	92	4.40	77	
M-160	11001.7	0863.3	M-160-24	-49.5	ALLUVIUM	8.0	17									74	
M-160	11001.7	0863.3	M-160-21	-50.5	ALLUVIUM	7.7	10									71	
M-160	11001.7	0863.3	M-160-18	-49.5	ALLUVIUM	6.9	20									70	
M-160	11001.7	0863.3	M-160-15	-39.5	ALLUVIUM	7.4	23									72	
M-160	11001.7	0863.3	M-160-13	-29.5	ALLUVIUM	6.3	11									56	
M-160	11001.7	0863.3	M-160-10	-20.0	ALLUVIUM	5.7	12									61	
M-160	11001.7	0863.3	M-160-9	-14.5	ALLUVIUM	8.2	15									76	
M-160	11001.7	0863.3	M-160-0	-9.5	ALLUVIUM	9.0	16									64	
M-160	11001.7	0863.3	M-160-6	-5.0	ALLUVIUM	9.5	24	5.5	1.60	20		61	22000	160	12.40	70	
M-302	10441.9	9472.4	M-30-10	-71.2	ALLUVIUM	7.9	20		0.60	23		78	31000	72	10.70	74	
M-302	10441.9	9472.4	M-30-16	-63.0	ALLUVIUM	7.9	15									67	
M-302	10441.9	9472.4	M-30-14	-54.0	ALLUVIUM	6.0	16									52	
M-302	10441.9	9472.4	M-30-12	-44.0	ALLUVIUM	6.0	85									70	
M-302	10441.9	9472.4	M-30-10	-35.5	ALLUVIUM	7.3	11									66	
M-302	10441.9	9472.4	M-30-0	-24.0	ALLUVIUM	6.9	10		0.50	20		50	19000	54	10.60	67	
M-302	10441.9	9472.4	M-30-6	-14.0	ALLUVIUM	5.5	16									60	
M-302	10441.9	9472.4	M-30-5	-9.2	ALLUVIUM	6.2	16									68	
M-302	10441.9	9472.4	M-30-4	-4.0	ALLUVIUM	5.7	22									61	
M-65	9779.1	0731.9	M-65-4-dup	-21.5	ALLUVIUM	6.9	10									74	
M-65	9779.1	0731.9	M-65-4	-21.5	ALLUVIUM	6.6	16		0.70	22		69	34000	13	14.40	74	
M-65	9779.1	0731.9	M-65-3	-16.5	ALLUVIUM	7.4	20									74	
M-65	9779.1	0731.9	M-65-2	-11.5	ALLUVIUM	7.1	20									74	
M-65	9779.1	0731.9	M-65-1	-1.5	ALLUVIUM	5.5	29									77	

NOTES:

1) Value for analyte on left is concentration in mg/kg (ppm).

2) Distance from top of alluvium refers to the distance above or below the fill/alluvium contact.

ALLUVIUM AVERAGE	6.9	20.9	4.7	0.9	23.0	0.8	50.6	24750.0	71.9	12.8
ALLUVIUM MAXIMUM	10.9	85.0	6.0	1.6	39.0	1.8	70.0	34000.0	160.0	26.9
ALLUVIUM STD DEV	1.6	12.6	1.0	0.4	7.4	0.3	10.6	5471.5	39.5	6.7
NUMBER OF SAMPLES	53.0	53.0	5.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0

The relationships of the concentrations versus depth for pH, lead, arsenic, cadmium, chromium, hexavalent chromium, zinc, iron and sulfate are shown on Figures D6-1 through D6-12 (Appendix D6). Figures D6-1 and D6-2 summarize results for lead in all borings and wells that were sampled. Figures D6-3 through D6-12 show lead versus distance from the fill/alluvium contact in Borings B-5, B-6, B-8 and B-10, and wells W-3D2, W-6S, W-7S, W-11D, W-15D and W-15S and W-16D, (W-12D included with B-8, which is at the same location as are W-16D and W-16S).

Figures D2.3-13 to D2.3-20 show the relationship of concentration to distance from the fill/alluvium contact for arsenic, cadmium, chromium, zinc, iron, sulfate and pH (respectively) for all samples.

As shown on Table 4.5-3, concentrations of the analytes evaluated are generally low, except for iron, which is a major constituent of the natural minerals which comprise the alluvium. Indeed, they generally are lower than the range of background concentrations that have been reported for the area, or were found in the background samples taken for this study (Section 3.0). Background sample locations are shown on Figure 4.5-13.

The contaminant concentrations in the alluvium suggests that transport of significant amounts of contaminated material from the fill has not occurred. The potential transport pathways are precipitation of dissolved species, mechanical transport of contaminated sediments, and adsorption of dissolved species. This situation would be expected because of the low solubility of lead and other metals, and the low mobility of sediments.

4.5.2.4 Columbia River Basalt

No chemical analyses were performed on samples of the Columbia River Basalt, because the only samples collected were grab samples of drill cuttings. Iron and trace metal composition of the basalt are reported by Wright et al. (1979). Ranges of reported values are summarized in Table 4.5-4.

TABLE 4.5-4

ELEMENTAL CONCENTRATIONS IN BASALT

<u>Element</u>	<u>Concentration (ppm)</u>	
	<u>BCR-1</u>	<u>Frenchman Springs</u>
Lead	17.6ppm	NA
Arsenic	0.7	NA
Cadmium	0.12	NA
Chromium	17	20-40
Zinc	120	200
Iron	100,000	100,000 - 110,000
Sulfur	392	NA

NA - Data not available

BCR-1: Columbia River Basalt Chemical Standard

Source: Wright et al. 1979

4.5.3 Ground-Water Contaminant Delineation

Results of ground-water sample analyses from the water-bearing units are presented in Tables 4.5-5 and 4.5-6. Table 4.5-5 summarizes results for metals, pH, sulfate and TOC for each of the hydrostratigraphic units discussed in this subsection. Table 4.5-6 presents average, standard deviation, minimum and maximum values for the aforementioned analytes.

Table 4.5-7 shows correlation coefficients between pH and the various dissolved constituents on site. Higher dissolved lead, zinc, chromium, and sulfate are all more highly correlated with low pH (a negative correlation) compared to the other constituents. This indicates that pH, sulfate and dissolved lead may be useful as primary indicators of contaminants related to activities at the Gould site. One exception to this is high sulfate encountered at well RPW-4, which is upgradient of the Gould property. This may indicate that sulfate contamination is not unique to Gould's activities. The low correlation between arsenic and pH may indicate that this contaminant also may not be related solely to the activities of Gould. If low pH, high dissolved lead, and/or high dissolved sulfate exists at a well, it can be expected

TABLE 4.5-6

SHEET 1 OF 3

STATISTICAL EVALUATION OF GROUND WATER CHEMISTRY RESULTS, ROUNDS 1,2 and 3

SAMPLE	ROUND	DATE	TOTAL FC	EC	RES FC	RES AS	RES CB	RES CL	RES ZN	RES CO	RES SO4	TP
SAMPLES FROM BASALT AQUIFER												
W-06B	B	1	7.6		0.02	0.005	0.002	0.005	0.002	0.44	52	
W-06B-dup	B	1	7.5		0.02	0.005	0.002	0.005	0.002	0.32	45	
W-11B	B	1	7		0.02	0.005	0.002	0.004	0.005	0.5	36	
W-06B	B	2	7.3	0.01	0.01	0.01	0.005	0.002	0.005	0.003	0.01	76
W-11B	B	2	7.2	0.01	0.01	0.01	0.005	0.002	0.005	0.004	0.2	14
W-06B	B	3	6.7	0.01	0.01	0.01	0.005	0.002	0.005	0.004	0.04	9.4
W-11B	B	3	6.5	0.01	0.01	0.01	0.005	0.002	0.005	0.046	0.59	5.1
AVERAGE			7.1	0.010	0.010	0.014	0.005	0.002	0.005	0.010	1.16	42
STD. DEV			0.4	0.000	0.000	0.005	0.000	0.000	0.000	0.015	2.19	9
nSTD. DEV			6.4	0.000	0.000	0.005	0.000	0.000	0.000	0.015	2.19	9
AVG+nSTD			7.5	0.010	0.010	0.019	0.005	0.002	0.005	0.025	3.35	51
AVG-nSTD			6.7	0.010	0.010	0.009	0.005	0.002	0.005	-0.005	-1.03	33
MIN			6.7	0.010	0.010	0.010	0.005	0.002	0.005	0.002	0.01	32
MAX			7.6	0.010	0.010	0.020	0.005	0.002	0.005	0.046	6.50	52
NO. ANALYSES			7	4	4	7	7	7	7	7	7	4
n (FOR n STD)			1	1	1	1	1	1	1	1	1	1
SAMPLES FROM LOWER PART OF ALLUVIAL AQUIFER												
RFW-4B	B	1	6.6		0.01	0.005	0.002	0.005	0.006	0.3	1100	
W-01B	B	1	6.5		0.01	0.005	0.002	0.005	0.016	3.3	15	
W-02B	B	1	5.8		0.21	0.61	0.002	0.01	6.5	570	14000	
W-06B	B	1	6.9		0.01	0.005	0.002	0.017	0.006	6.7	17	
W-07B	B	1	3.4		0.17	0.012	0.002	0.17	11	2500	20000	
W-08B	B	1	6.5		0.02	0.005	0.002	0.005	0.004	34	41	
W-11B	B	1	6.8		0.01	0.005	0.002	0.005	0.006	2.9	200	
W-15B	B	1	4.6		0.01	0.005	0.002	0.005	0.018	210	1500	
RFW-4B	B	2	6.4	0.01	0.01	0.01	0.005	0.002	0.005	0.013	0.01	410
W-01B	B	2	6.4	0.01	0.01	0.01	0.005	0.002	0.005	0.015	0.01	8.3
W-02B	B	2	6	1.7	1.8	0.03	0.13	0.002	0.016	5	6300	14000
W-03B(2)	B	2	6.9	0.01	0.01	0.01	0.01	0.002	0.005	0.018	0.71	4
W-06B	B	2	7.1	0.01	0.01	0.01	0.006	0.002	0.005	0.002	0.62	22
W-07B	B	2	3.9	0.16	0.15	0.12	0.017	0.005	0.2	13	4500	31000
W-08B	B	2	6.5	0.06	0.05	0.02	0.005	0.002	0.005	0.009	160	5
W-11B	B	2	6.5	0.02	0.03	0.01	0.005	0.002	0.005	0.003	0.01	180
W-12B	B	2	7.6	0.04	0.01	0.01	0.005	0.002	0.005	0.021	0.01	14
W-15B	B	2	6.5	0.01	0.01	0.01	0.005	0.002	0.005	0.25	67	340
W-16B	B	2	7.6	0.01	0.01	0.01	0.005	0.002	0.005	0.013	3.5	16
RFW-4B	B	3	6.4	0.01	0.01	0.01	0.005	0.002	0.005	0.27	22	1900
W-01B	B	3	5.8	0.01	0.01	0.01	0.005	0.002	0.005	0.01	0.08	20
W-02B	B	3	4.3	0.49	0.48	0.03	0.14	0.002	0.008	5.9	3200	17000
W-02B-dup	B	3	4.2	0.5	0.49	0.05	0.28	0.002	0.009	6.9	3900	18000
W-03B(2)	B	3	7.7	0.05	0.04	0.01	0.03	0.002	0.005	0.039	0.03	9
W-06B	B	3	6.6	0.04	0.01	0.01	0.016	0.002	0.005	0.011	9.9	14
W-07B	B	3	3.9	0.01	0.01	0.07	0.019	0.003	0.14	8.3	1800	26000
W-07B-dup	B	3	3.8	0.07	0.06	0.06	0.017	0.004	0.14	7.9	1800	39000
W-08B	B	3	6.4	0.23	0.1	0.02	0.005	0.002	0.005	0.084	50	11
W-11B	B	3	6.5	0.07	0.07	0.03	0.005	0.002	0.005	0.089	2.9	200
W-12B	B	3	6.9	0.06	0.03	0.01	0.005	0.002	0.005	0.041	0.06	11
W-12B-dup	B	3	6.8	0.01	0.01	0.01	0.005	0.002	0.005	0.041	0.06	11
W-15B	B	3	6.7	0.01	0.01	0.01	0.005	0.002	0.005	0.01	12	160
W-16B	B	3	6.6	0.01	0.01	0.01	0.005	0.002	0.005	0.006	0.33	4
AVERAGE			6.1	0.144	0.138	0.032	0.042	0.002	0.025	1.985	762.32	5646.4
STD. DEV			1.2	0.344	0.363	0.047	0.114	0.001	0.052	3.656	1550.62	10328.7
nSTD. DEV			1.2	0.344	0.363	0.047	0.114	0.001	0.052	3.656	1550.62	10328.7
AVG+nSTD			7.3	0.489	0.500	0.078	0.156	0.003	0.077	5.641	2312.94	15975.0
AVG-nSTD			4.9	-0.200	-0.225	-0.015	-0.036	0.002	-0.027	-1.671	-788.31	-4682.3
MIN			3.4	0.010	0.010	0.010	0.005	0.002	0.005	0.002	0.01	2.0
MAX			7.6	1.700	1.800	0.210	0.610	0.005	0.200	13.000	6300.00	39000.00

TABLE 4.5-6

STATISTICAL EVALUATION OF GROUND WATER CHEMISTRY RESULTS, ROUNDS 1, 2 and 3

SAMPLE	ROUND	pH-T	TOTAL FD	T.R.FD	DIS FB	DIS AS	DIS CD	DIS CR	DIS ZN	DIS FE	DIS SO4	100
SAMPLES FROM UPPER AND MIDDLE PART OF ALLUVIAL AQUIFER												
W-03B	1	1	6.2		0.03	0.021	0.002	0.013	0.07	420	3400	
W-04B	1	1	6.5		0.03	0.031	0.002	0.005	0.16	460	96	
W-06B	1	1	6.8		0.12	0.011	0.002	0.005	0.091	7.9	4	
W-07B	1	1	7.1		0.04	0.05	0.002	0.005	0.022	3.4	5	
W-10B	1	1	4.4		0.02	0.005	0.002	0.005	0.005	450	120	
W-111	1	1	6.8		0.03	0.019	0.002	0.11	0.08	39	49	
W-151	1	1	2.9		0.02	0.018	0.002	0.013	0.033	6600	15000	
W-151 dup	1	1	2.9		0.02	0.005	0.002	0.01	0.031	6300	15000	
FF-08	1	2	6.7	0.02	0.02	0.035	0.002	0.005	0.019	42	590	30
FF-11	1	2	6.3	1	0.02	0.01	0.005	0.002	0.005	0.024	38	48
W-03B	1	2	6.1	0.02	0.02	0.03	0.005	0.002	0.005	0.032	2500	30
W-04B	1	2	6.7	0.02	0.02	0.01	0.01	0.002	0.005	0.015	290	53
W-06B	1	2	6.9	0.02	0.02	0.01	0.005	0.002	0.005	0.014	0.01	120
W-07B	1	2	7	0.04	0.04	0.01	0.024	0.002	0.005	0.014	0.01	120
W-10B	1	2	6.4	0.04	0.04	0.02	0.005	0.002	0.005	0.015	330	50
W-111	1	2	6.8	0.01	0.01	0.01	0.012	0.002	0.005	0.02	20	48
W-121	1	2	8.4	0.01	0.01	0.01	0.006	0.002	0.005	0.009	0.08	250
W-151	1	2	5.8	0.02	0.01	0.02	0.008	0.002	0.005	0.044	15000	28
W-161	1	2	7.7	0.01	0.01	0.02	0.005	0.002	0.005	0.003	0.01	56
FF-08	1	3	6.5	0.05	0.05	0.01	0.048	0.002	0.005	0.013	8.3	40
FF-11	1	3	6.2	0.38	0.37	0.01	0.005	0.002	0.005	0.079	8.3	10
W-03B	1	3	6	0.02	0.02	0.02	0.018	0.002	0.005	0.016	720	8.9
W-04B	1	3	6.5	0.02	0.02	0.01	0.018	0.002	0.005	0.007	30	9.7
W-04B dup	1	3	6.5	0.03	0.02	0.01	0.019	0.002	0.005	0.005	30	8.7
W-06B	1	3	6.5	0.05	0.04	0.02	0.021	0.002	0.005	0.015	4.4	24
W-06B dup	1	3	6.5	0.05	0.04	0.02	0.021	0.002	0.005	0.015	4.4	19
W-07B	1	3	6.9	0.05	0.05	0.02	0.011	0.002	0.007	0.06	2.5	84
W-10B	1	3	6.1	0.04	0.02	0.02	0.005	0.002	0.005	0.058	130	16
W-111	1	3	6.6	0.02	0.02	0.01	0.005	0.002	0.005	0.073	6.6	33
W-121	1	3	7.6	0.21	0.2	0.01	0.01	0.002	0.005	0.045	0.06	80
W-151	1	3	6	0.02	0.02	0.01	0.017	0.002	0.005	0.035	2100	1
W-161	1	3	7.1	0.01	0.01	0.01	0.009	0.002	0.005	0.004	0.01	9.6
AVERAGE			6.4	0.09	0.05	0.02	0.0	0.002	0.009	0.035	1111	52.6
STD. DEV			1.1	0.21	0.08	0.02	0.0	0.000	0.018	0.034	2962	52.8
STD. DEV			1.1	0.21	0.08	0.02	0.0	0.000	0.018	0.034	2962	52.8
AVERAGE			7.5	0.30	0.12	0.04	0.0	0.002	0.027	0.069	4073	105.4
AVERAGE			5.3	0.12	0.03	0.00	0.0	0.002	0.002	0.002	-1851	0.2
MIN			2.9	0.01	0.01	0.01	0.0	0.002	0.005	0.003	0	6.9
MAX			8.4	1.00	0.37	0.12	0.1	0.002	0.110	0.160	15000	250.0
NO. ANALYSES			32	24	24	32	32	32	32	32	32	24
n (FOR n STD)			1	1	1	1	1	1	1	1	1	1

TABLE 4.5-6

STATISTICAL EVALUATION OF GROUND WATER CHEMISTRY RESULTS, ROUNDS 1,2 and 3

SAMPLE	ROUND	pH-F	TOTAL FB	T-K-FB	DIS FB	DIS AS	DIS CD	DIS CR	DIS ZN	DIS FF	DIS SO4	TOC	
SAMPLES FROM FILL ADJUTEN													
W-075	S	1	6.7		0.02	0.009	0.002	0.005	0.002	8.9	306		
W-115	S	1	11.6		0.02	0.05	0.002	0.009	0.008	0.56	36		
W-155	S	1	12.5		0.02	0.005	0.002	0.005	0.004	2.2	9		
FF-06	S	2	7	0.82	0.82	0.11	0.03	0.002	0.005	0.037	0.01	54	36
F-01	S	2	6.9	0.01	0.01	0.01	0.006	0.002	0.005	0.019	0.02	32	5.6
F-02	S	2	6.4	0.27	0.26	0.01	0.15	0.002	0.005	0.59	240	720	6.3
F-03	S	2	6.8	0.01	0.01	0.01	0.005	0.002	0.005	0.009	0.01	320	6.7
F-04	S	2	10.1	0.09	0.09	0.01	0.034	0.002	0.005	0.006	0.01	100	29
W-075	S	2	6.8	1.8	1.8	0.01	0.008	0.002	0.01	0.008	5.1	310	23
W-115	S	2	11.7	0.01	0.01	0.01	0.014	0.002	0.005	0.013	0.01	30	33
W-155	S	2	12	0.01	0.01	0.01	0.005	0.002	0.005	0.033	0.01	17	8.7
W-165	S	2	12.5	0.01	0.01	0.01	0.018	0.002	0.005	0.017	0.01	14	16
FF-05	S	3	7	3.3	3.3	0.01	0.066	0.002	0.005	0.007	0.32	60	26
F-01	S	3	6.2	0.04	0.04	0.01	0.022	0.002	0.005	0.009	5.2	21	5
F-02	S	3	6	0.4	0.39	0.01	0.18	0.002	0.005	0.17	55	450	7
F-02-dup	S	3	5.8	0.21	0.21	0.01	0.15	0.002	0.005	0.16	48	410	6.8
F-03	S	3	6.9	0.01	0.01	0.01	0.005	0.002	0.005	0.02	0.01	270	7.2
F-04	S	3	9.2	0.03	0.02	0.01	0.015	0.002	0.005	0.006	0.8	80	22
W-075	S	3	6.7	4.8	4.7	0.02	0.005	0.002	0.005	0.068	2	160	27
W-075-dup	S	3	6.7	5.9	5.8	0.02	0.005	0.002	0.005	0.072	6.2	170	18
W-115	S	3	11.4	0.12	0.12	0.01	0.011	0.002	0.005	0.01	0.63	28	29
W-155	S	3	11.5	0.23	0.2	0.01	0.01	0.002	0.005	0.002	0.07	22	9.4
W-155-dup	S	3	11.5	0.27	0.26	0.01	0.01	0.002	0.005	0.005	0.01	19	8.6
W-165	S	3	12.3	3.2	3	0.02	0.74	0.002	0.005	0.002	0.04	130	36
AVERAGE			8.8	1.03	1.00	0.02	0.065	0.002	0.005	0.053	16	157	17.2
STD. DEV			2.5	1.71	1.67	0.02	0.149	0.000	0.001	0.121	49	178	10.8
nSTD. DEV			2.5	1.71	1.67	0.02	0.149	0.000	0.001	0.121	49	178	10.8
AUG-toSTD			11.4	2.73	2.68	0.04	0.214	0.002	0.007	0.174	64	335	27.9
AVG-nSTD			6.3	-0.68	-0.67	-0.00	-0.085	0.002	0.004	-0.067	-33	-21	6.1
MIN			5.8	0.01	0.01	0.01	0.005	0.002	0.005	0.002	6	9	5.6
MAX			12.5	5.90	5.80	0.11	0.740	0.002	0.010	0.590	240	720	36.0
#OF ANALYSES			24	21	21	24	24	24	24	24	24	21.0	
n (FOR n STD)			1	1	1	1	1	1	1	1	1	1.0	
Average all samples													
AVERAGE			6.9	0.37	0.35	0.02	0.036	0.002	0.013	0.708	636.298	2824.8	37
STD. DEV			1.9	1.03	1.01	0.03	0.103	0.000	0.033	2.335	1989.437	7141.3	35
nSTD. DEV			1.9	2.05	2.01	0.06	0.205	0.001	0.067	4.670	3978.875	14282.7	129
AUG-toSTD			8.8	2.42	2.36	0.09	0.242	0.003	0.080	5.378	4615.173	17107.5	102
AVG-nSTD			5.0	-1.68	-1.67	-0.04	-0.169	0.001	-0.053	-3.962	-3342.576	-11457.851	-27
MIN			3.0	0.00	0.00	0.00	0.00	0.002	0.005	0.002	0.010	1.000	2
MAX			12.5	5.90	5.80	0.21	0.740	0.005	0.200	13.000	15000.000	39000.6	410
#OF ANALYSES			96.0	74.0	74.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	74
n (FOR n STD)			1.0	NA	NA	2.0	2.0	2.0	2.0	2.0	NOT AFFI	2.0	1

TABLE 4.5-7

CORRELATION BETWEEN pH AND DISSOLVED CONSTITUENTS

Dissolved Contaminant Correlations	Correlation Coefficient	
	In Alluvium	In Fill
pH versus Dissolved SO ₄	-.77	-.49
pH versus Dissolved Pb	-.75	-.37
pH versus Dissolved Zn	-.75	-.40
pH versus Dissolved Cr	-.73	--
pH versus Dissolved K	-.71	+.69
pH versus Dissolved Fe	-.46	-.39
pH versus Dissolved As	-.18	+.40
pH versus Dissolved Cl	-.22	-.43
pH versus Dissolved Ec	-.58	+.61
pH versus Dissolved TOC	+.17	+.37
pH versus Dissolved Mg	-.59	-.71
pH versus Dissolved Na	-.18	+.25
pH versus Dissolved NO ₃	-.49	+.49
pH versus Dissolved PO ₄	-.26	+.37
pH versus Dissolved Ca	-.36	+.26

*The square of the correlation coefficient provides an estimate of the percent variation in the dependent variable explained by the independent variable (pH). Only SO₄, Pb, Zn and Cr in the alluvium exhibit percent variation explained above 50 percent.

that there are higher levels of zinc and chromium as well. This section will focus primarily on sulfate and lead levels in the ground water as an indicator of contamination related to Gould activities. Other contaminants will be addressed in relation to lead and sulfate.

Background for sulfate and other parameters can be approximated by comparison with water samples from the wells in the basalt water-bearing unit, as discussed in the subsequent subsection 4.5.3.4. By this comparison, samples with sulfate greater than approximately 50 ppm are above background. In this case, wells/piezometers which show average sulfate levels greater than 50 ppm appear to represent a sulfate "plume" that may have originated from disposal of battery acid and casing fragments. This sulfate "plume" may transport lead and other soluble metals until the pH is buffered by the natural buffering capacity of the soils in the fill and alluvium. When the pH is buffered, the metals may be removed from solution by precipitation. Background levels for dissolved, total recoverables, and total lead, as indicated in the basalt aquifer water chemistry, are equal to or below 0.01 ppm.

4.5.3.1 Lead in Ground Water

Three different lead analyses were conducted on the ground-water samples from the site. Water samples were unfiltered prior to analyzing for total lead and total recoverable lead, and filtered prior to analysis of dissolved lead. Dissolved lead represents the fraction of lead in solution determined with no predigestion of the sample. Total lead and total recoverable lead represent the fraction of lead present in the sample that is obtainable after differing levels of digestion, with total lead representing a more complete digestion than total recoverable lead. Total and total recoverable lead in the samples includes lead that may be adsorbed, held onto or are part of colloidal or small sediment particles. Lead that is identified as total recoverable can be considered a combination of lead that is held by colloidal particles, and dissolved lead. Total lead includes all digestible lead, including some that can be considered unavailable for reaction.

In general, the ground-water samples at all wells show total and total recoverable lead to be nearly equal. This indicates that the total

lead in the sample is present due to a reactive or depositional process that has removed dissolved lead from solution. The total recoverable lead may be indicative of higher dissolved lead in the past that has subsequently precipitated, adsorbed, or complexed with fine colloidal sediments in the formation, even though present dissolved lead levels are not high, or the presence of total recoverable lead may be indicative of processes that have gradually removed lead from dilute solutions. In addition, a process of colloidal sediment transport of lead may have been responsible for some lead transport.

The levels of total recoverable lead measured in the ground-water samples fluctuated widely between sampling rounds. In some cases, a twenty-fold increase in total recoverable lead was measured between sampling rounds with no attendant pH, dissolved lead, or other chemical differences. This type of variation indicates that the variation is a result of sampling or well differences rather than a change in water quality. For example, if fine sediments were disturbed during the sampling process, more colloidal material might be present in the sample.

The variation and lack of consistency between sampling dates for total recoverable lead and the balance between total lead, total recoverable lead and dissolved lead, indicates that the measured values of total recoverable lead can only have limited interpretative value. Where total recoverable lead has been observed to be greater than the MCL for lead, there is a possibility that the colloidal sediments carrying the lead (detected as recoverable lead) could represent an exposure pathway. Therefore, the existence of total recoverable lead above MCL should be evaluated in the same light as a dissolved lead level greater than MCL.

Total recoverable lead levels above MCL have been observed in wells PP-11, W-2D, W-7D, W-8D, W-11D, W-12I, P-02, P-04, PP-06, W-7S, W-11S, W-15S, and W-16S (Figures 4.5-14 to 4.5-16). The presence of total recoverable lead at these locations may indicate that lead has precipitated onto sediments as a result of a wider dissolved lead plume in the past; that the soil matrix has been complexing with dissolved lead as ground water moves away from East Doane Lake in a northerly, westerly, and southerly direction (acting as a lead buffer); or that lead has migrated

in some other fashion, such as on colloidal particulates. The latter mechanism would appear to be the least likely, given the general fine-grained sediments of the area (refer to Section 4.5.5.3). The existence of high total recoverable lead in well PP-11 may indicate that ground water has migrated preferentially along the utility line underneath NW Front Street, carrying lead and depositing it at this location.

Dissolved lead concentrations above MCL are presently confined to ground water around wells W-7D, W-2D, and W-6S in the alluvium and PP-06 in the fill. These high dissolved lead values also correspond to lower pHs, and elevated dissolved iron, sulfate, and chromium, in general. Dissolved arsenic above MCLs (0.05 ppm) has been observed at wells P-2, W-16S, and PP-06, all in the fill aquifer and at well W-2D in the alluvial aquifer. Arsenic at W-16S is not associated with high dissolved sulfate or dissolved lead.

4.5.3.2 Fill Water-Bearing Unit

Several of the wells and piezometers completed in the fill are located in or very near to the battery casing fragments (P-2, PP-6, W-7S) or the East Doane Lake remnant (P-3, P-4, W-15S). Samples of water from three of these wells/piezometers contain sulfate in excess of 100 ppm (P-2, P-3, W-7S), as shown on Table 4.5-5. Ground water from W-16S, located next to the Liquid Air facility, also has sulfate >100 ppm.

The general outline of the sulfate "plume" is shown in Figure 4.5-17. Shown on the figure are the areas of elevated sulfate concentrations and dissolved lead concentrations greater than or equal to 0.02 ppm. The concentration contours are based on the observed values for sulfate and lead which are above background.

The relationship of low pH and high sulfate indicates that the sulfuric acid from East Doane Lake may have migrated to the west. The lower pH, in turn, has increased the amount of lead in solution by increasing the solubility limit.

The area of higher sulfate correlates with lower pH values and elevated metal concentrations. Well PP-6 shows the only dissolved lead

values above the maximum allowable for drinking water (Table 4.5-5). Wells W-16S, P-2, and PP-6 show levels of dissolved arsenic above drinking water standards. Levels of zinc are significantly elevated as compared to surrounding wells at well P-2. Applicable Federal Standards (MCLs) for metals are presented in Table 4.5-8.

TABLE 4.5-8

FEDERAL STANDARDS FOR METALS

Parameter	Maximum Level (Drinking Water) (mg/l)	Maximum Level (EPA EP Toxicity Protocol) (mg/l)
Arsenic	0.05	5.0
Barium	1.0	100.0
Cadmium	0.01	1.0
Chromium	0.05	5.0
Lead	0.05	5.0
Mercury	0.002	0.2
Selenium	0.01	1.0
Silver	0.05	5.0

4.5.3.3 Upper Alluvial Water-Bearing Unit

Results of ground-water sample analyses from the upper alluvial water-bearing unit are presented in Tables 4.5-5 and 4.5-6. Table 4.5-5 summarizes results for metals, pH, sulfate and TOC for each of the hydrostratigraphic units discussed in this subsection. Table 4.5-6 also presents average, standard deviation, minimum and maximum values for the aforementioned analytes.

None of the wells completed in the upper alluvial water-bearing unit are located below or very near to the battery casing fragments. However, W-3D, W-4D and W-15I are located immediately adjacent to the East Doane Lake remnant. Samples of water from W-3D, W-4D, and W-15I contain high sulfate concentrations. Sulfate in W-3D remained fairly constant (3,400 ppm, 4,900 ppm, and 3,300 ppm during rounds 1, 2, and 3, respectively). W-15I increased from 15,000 ppm during round 1 to 22,000 ppm during round 2, and then decreased to 8,800 ppm during round 3.

However, water from W-4D, located between W-3D and W-15I (Figure 4.5-1) has lower sulfate concentrations. Sulfate concentrations in W-4D declined from a high of 96 ppm during round 1 to 1 ppm during rounds 2 and 3 (Table 4.5-5).

Wells W-10D and W-12I, and piezometer PP-8 also have sulfate values which appear to be elevated above background. In this case, the elevated sulfate concentrations in wells W-3D, W-10D, W-12I, W-15I and PP-8 also appear to represent a sulfate "plume" that may have originated from disposal of battery acid and casing fragments. As discussed previously, this sulfate "plume" may transport lead and other soluble metals until the pH is buffered or lead is complexed by the natural buffering capacity of the soils in the fill and alluvium. Wells W-3D, W-4D, W-6S, W-10D, W-11I and W-9D have shown lead above 0.02 ppm, and only W-3D and W-10D have shown lead above this during two sampling rounds (Table 4.5-5). The theoretical solubility of lead at these wells is greater than 0.02 ppm (refer to Section 4.5.5.2), thus it appears that soluble lead migration may indeed be inhibited as the sulfate "plume" migrates away from the source. This indication of inhibition supports a theory that past releases of acidic water from the site were not large enough to exhaust the exchange capacity of the soil.

A similar trend is observed in this water-bearing unit as compared with the fill. Both show elevated dissolved metals, including zinc, arsenic, iron and chromium, and sulfate levels in association with lower pH values. As has been indicated previously, high sulfate is not necessarily associated with high dissolved metals and low pH, however, the association of elevated levels of dissolved metals and sulfate with low pH is stronger in the alluvium as a whole as compared with the fill. This indicates that the distribution of these contaminants has been less dispersed or diluted by ground-water movement.

The sulfate "plume" with associated low pH has migrated west as shown in Figure 4.5-18. Increased dissolved metal concentrations appear to be the result of the lower pH which increases the solubility of metals, thus carrying high levels of these species as the "plume" migrates. Figure 4.5-18 shows the general region of high sulfate, high

dissolved metals and low pH for the upper alluvium. The concentration contours are based on the maximum observed values for sulfate and lead.

Well W-11I also shows chromium levels above drinking water standards on one sampling date, however, other samples show levels below detection limit.

4.5.3.4 Lower Alluvial Water-Bearing Unit

Results of ground-water sample analyses from the lower alluvial water-bearing unit are presented in Tables 4.5-5 and 4.5-6. Table 4.5-5 summarizes results for metals, pH, sulfate and TOC for each of the hydrostratigraphic units discussed in this subsection. Table 4.5-6 presents average, standard deviation, minimum and maximum values for the aforementioned analytes.

Two of the wells completed in the lower alluvial water-bearing unit are located below or very near to the battery casing fragments (W-2D, and W-7D). In addition, W-15D is located immediately adjacent to the East Doane Lake remnant. Samples of water from W-2D contain high sulfate concentration. Sulfate in W-2D remained fairly constant (14,000 ppm during rounds 1 and 2, and 17,000 ppm during round 3). Sulfate concentrations from W-15D decreased from 1,500 ppm during round 1 to 340 ppm during round 2 to 180 ppm during round 3.

Well W-11D also has sulfate values which appear to be elevated above background, at a relatively constant concentration of 180 ppm to 200 ppm. The elevated sulfate in wells W-2D, W-7D, W-11D, and W-15D also appears to indicate a sulfate "plume" that may have originated from disposal of battery acid and casing fragments. This sulfate "plume" may transport lead and other soluble metals. Average dissolved lead concentrations have been observed to be greater than 0.02 ppm only in well W-2D. In addition, well W-2D has shown lead concentrations above 0.05 ppm (Table 4.5-5). Thus, it appears that elevated concentrations of lead currently reach the lower alluvial water-bearing zone only in the area immediately below the battery casing fragments. This finding lends additional support to the hypothesis that no substantial releases of lead above 0.05 ppm has taken place.

Well RPW-4 also has an apparently elevated sulfate concentration. Because it is "upgradient" of the other wells with high sulfate, it could be argued that sulfate from off site is a contributing factor to onsite contaminant migration. However, the two wells immediately down-gradient from RPW-4 (W-1D and W-6D) have low sulfate values.

Figure 4.5-19 shows the estimated contaminant "plume" as it exists in the lower alluvium. The concentration contours are based on the maximum observed concentration for sulfate and lead. Wells W-2D and W-7D are the only wells that show dissolved lead above drinking water standards.

4.5.3.5 Basalt Water-Bearing Unit

Results of ground-water sample analyses from the basalt water-bearing unit are presented in Tables 4.5-5 and 4.5-6. Table 4.5-5 summarizes results for metals, pH, sulfate and TOC for each of the hydrostratigraphic units discussed in this subsection. Table 4.5-5 presents average, standard deviation, minimum and maximum values for the aforementioned analytes.

Analyses of water from the basalt indicate that sulfate, pH, and metals are generally within the ranges reported for the basalt aquifer in the area (Hart and Newcomb, 1965). The one apparent exception to this situation appears to be a reported concentration of 0.046 ppm zinc in well W-11B during round 3. Dissolved lead concentrations in the basalt aquifer are less than 0.01 ppm.

4.5.3.6 Summary

The potential for dissolved lead values to occur at concentrations above the drinking water standard of 0.05 ppm exists in the fill, upper alluvial and lower alluvial water-bearing units in the region below the Gould site where battery casings and sulfuric acid have been deposited. In general, values above 0.05 ppm are also associated with other elevated dissolved metals, primarily zinc, arsenic, chromium, iron, and elevated sulfate and lower pH. Low pH and sulfate concentrations greater than 50 ppm serve as indicators of potentially elevated dis-

solved metal concentrations, including lead. The identified extent of the sulfate "plume" indicates that it has migrated as far as well W-10D in the upper alluvium. The maximum dissolved lead concentrations diminish moving away from East Doane Lake and wells W-2 and W-7, indicating that dissolved lead migration is being retarded. Dissolved lead values above drinking water standards exist only in wells W-7D and W-2D in the lower alluvium, and in well PP-6 in the fill. These locations are directly beneath the battery casing piles. Wells W-2D and W-7D also show pH values below 6.0. The distribution of total recoverable lead may indicate that dissolved lead is, or at one time in the past was, accumulating in the soils.

The sulfate and lead migration distribution patterns indicate a source near the battery casing piles and East Doane Lake with a subsequent migration downgradient towards West Doane Lake and to the northeast, with the maximum migration occurring in the upper alluvium. The distribution patterns indicate considerable exchange capacity in the soil, thus leading to confidence in the hypothesis that no large-scale releases of dissolved lead in ground water occurred in the past. However, some lead may have been transported along the utility lines as far as wells PP-11 and W-10, indicated by the presence of total recoverable lead above 0.05 ppm in well PP-11 and elevated sulfate and dissolved lead above 0.02 ppm in well W-10D.

4.5.4 Surface Water Contaminant Delineation

4.5.4.1 Willamette River

The Oregon DEQ has conducted sampling for toxicants in sediment and water in the Willamette River adjacent to the Gould site (RM 6.8 to 7.1) from 1980 through 1982. Numerous metals, including lead, have been reported in these samples (Oregon DEQ, 1982). Lead concentrations in the water column during the 1982 survey ranged from 1.8 parts per billion (ppb) at the Burlington Northern Railroad bridge (RM 7.0) to 14.4 ppb at a storm drain near the Doane Lake area (RM 7.1). Lead was not detected in two other water samples taken at the railroad bridge (detection limit for lead in the 1982 survey was 1.0 ppb). More recent

sampling was conducted near the site between the Pennwalt dock and the Wacker outfall (Oregon DEQ, 1985). Dissolved lead concentrations in these samples, collected 200 feet offshore at depths between 2 and 15 meters, were all below the 1985 survey detection limit of 0.01 parts per million.

Lead concentrations in sediments were analyzed at two locations in 1982. Concentrations measured 2,800 ppb at a station on the east bank of the river downstream of the Burlington Northern bridge (RM 6.8) and 3,200 ppb at a river station near the Doane Lake area (RM 7.1). Sediment chemistry analyses performed by the USGS in 1974 measured much higher sediment lead concentrations at Willamette River sites between RM 6.0 and 8.5 (Rickert et al. 1977). Lead concentrations averaged 35 ppm in these samples and ranged from 25 to 40 ppm. These concentrations were for the fine-grained sediment fraction only (less than 20 micrometers in diameter). Concentrations from sediment samples containing all retained materials less than 2 millimeters in diameter averaged 18.6 ppm lead and ranged from 5 to 35 ppm.

Contaminants may be transported by the Willamette as dissolved compounds in suspension, or within the bed load of the river. Since dissolved metals tend to associate with particulate material, their transport is closely related to the type and quantity of loading carried by the river. This loading varies depending on the discharge and stage of the river. The upstream reach of the river is, in general, the erosional reach. During low-flow conditions, average velocity in this reach is more than seven times that of the two downstream reaches. During high-flow conditions, large quantities of bed load are transported in this reach. Newberg Pool is a lower, depositional reach. Fine bottom sediments tend to accumulate in this reach. The tidal reach is extensively dredged in its lower 14 miles to aid navigation and includes the primary depositional area of the Willamette River system.

Surface water from the Gould site is discharged into the river from the East Doane Lake remnant through a storm sewer outfall during high-water conditions. As part of the remedial investigation, surface water samples were taken in the river both upstream and downstream of the east

Doane Lake outfall. Chemical analysis indicates that dissolved lead concentrations upstream and downstream of the outfall are within both EPA National Drinking Water Standards and DEQ Willamette Basin Water Quality Standards.

4.5.4.2 East and West Doane Lake Remnants

During operations at the Gould site, waste products including sulfuric acid, lead and zinc dross, and battery casings were disposed of both on site and on surrounding properties. Sulfuric acid was discharged directly into the East Doane Lake remnant; battery casings and dross were used as fill along the edge of the east remnant.

Due to the topography of the site and surrounding area, surface water runoff transports contaminants on the ground surface or leaches contaminants out from the battery casing pile into the East Doane Lake remnant. Contaminant transport into the west remnant is also by surface water runoff from the western portion of adjacent properties. Overflow from the east remnant flows directly into the Willamette River through an overflow discharge pipe. As stated above, no known surface discharge exists from the west remnant. Lead also appears to be deposited within the sediments of both East and West Doane Lake remnants.

East remnant water is characterized by relatively high concentrations of dissolved lead (Round 1: 0.28 mg/l dissolved lead; Round 2: 0.13 mg/l total lead at bottom, 0.15 mg/l total lead at top) (Table 4.5-9). Surface-water data collected by Oregon DEQ during recycling operations in 1979 and 1981 indicate lead contamination. Data collected by Dames & Moore also indicate lead contamination (Oregon DEQ 1982). The surface-water samples from the west remnant generally contain low concentrations of lead. Surface water sampling locations are shown on Figure 4.5-20.

TABLE 4.5-9

SURFACE WATER - ROUND 1 (Aug - Sept, 1986), ROUND 2 (Dec, 1986 - Jan, 1987),
AND ROUND 3 (Feb, 1987) ANALYSIS RESULTS

MR. Gould: SURFACE WATER - ROUND 1 (Aug - Sept, 1986), ROUND 2 (Dec, 1986 - Jan, 1987), AND ROUND 3 (Feb, 1987) ANALYSIS RESULTS

D I M	ROUND	LAB#-SAMPLE#	DATE	pH	pH	tot. Ph	T.B. Ph	Diss. Ph	Diss. As	Diss. Cd	Diss. Cr	Diss. Zn	Diss. Fe	Diss. SO4	TOC	Diss. Cl	Diss. NO3(N)	DT P04(P)	Diss. Ca	Diss. K	Diss. Mg	Diss. Mn	EC	ALK.	HARD.	
SAMPLE #				field	lab	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	umho/cm	mg/L	mg/L		
WEST BOWNE LAKE REMNANTS																										
SM-02	1	98374 - 5	08/19/86	7.7	--	--	--	0.05	0.021	0.002	0.0050	0.043	0.40 B	67	--	180	0.050	1.600	14.0	12.00	5.60	280	870	290 B	50	
SM-02	3	2538 - 12	02/24/87	--	8.3	0.01	0.01	0.010	0.0050	0.0020	0.0050	0.017	0.14 B	75	12.00	48	0.80	0.039	22.0	7.50	4.50	120	470	140	84	
SM-02-dup	3	2538 - 13	02/24/87	--	8.5	0.02	0.02	0.010	0.005	0.0020	0.0050	0.013	0.02 B	90	12.00	64	0.59	0.030	23.0	7.50	4.50	100	440	140	84	
EAST BOWNE LAKE REMNANTS																										
SM-01	1	98420 - 1	08/20/86	6.3	6.9	--	--	0.28	0.0050	0.0020	0.005	0.038	0.18 B	390	--	84	2.10	0.008	150.0	4.80	12.00	65	1100	28	430	
SM-01B	2	1298 - 23	12/17/86	--	7.3	0.13	0.06	0.05	--	--	--	--	--	--	4.30	--	--	--	--	--	--	--	--	--	--	
SM-01B	3	2538 - 24	02/24/87	--	7.3	0.14	0.14	0.010	0.0050	0.0020	0.0050	0.040	0.06 B	180	3.70	39	1.10	0.0050	84.0	2.40	4.00	25	400	49	250	
SM-01B-dup	3	2538 - 26	02/24/87	--	7.2	0.15	0.15	0.010	0.0050	0.0020	0.0050	0.035	0.010	180	3.20	39	1.10	0.009	86.0	2.40	4.20	26	580	50	240	
SM-015	2	1298 - 24	12/17/86	--	7.9	0.15	0.14	0.07	--	--	--	--	--	--	2.60	--	--	--	--	--	--	--	--	--	--	
SM-015	3	2538 - 25	02/24/87	--	7.4	0.13	0.12	0.010	0.0050	0.0020	0.0050	0.028	0.15 B	180	4.10	41	1.00	0.0050	86.0	2.40	4.10	25	400	50	250	
SM-015-dup	3	2538 - 27	02/24/87	--	7.4	0.13	0.13	0.010	0.0050	0.0020	0.0050	0.041	0.05 B	180	4.30	38	2.20	0.0050	82.0	2.50	4.20	25	400	50	250	
SM-01-dup	1	98420 - 2	08/20/86	6.4	7.0	--	--	0.28	0.0050	0.0020	0.0050	0.033	0.17 B	390	--	82	2.10	0.007	140.0	4.70	11.00	64	1100	30	430	
SM-07B	2	1298 - 26	12/17/86	--	8.8	0.12	0.11	0.03	0.0050	0.0020	0.0050	0.015	0.010	360	3.60	7	1.40	0.0050	100.0	2.70	4.20	36	830	34	320	
SM-07B	3	2538 - 30	02/24/87	--	8.1	0.11	0.11	0.010	0.0050	0.0020	0.0050	0.025	0.04	180	4.50	39	1.70	0.0050	92.0	2.40	4.00	25	560	50	250	
SM-07S	2	1298 - 27	12/17/86	--	8.8	0.14	0.12	0.02	0.0050	0.0020	0.0050	0.024	0.010	310	3.70	58	1.30	0.021	120.0	2.60	4.20	37	830	33	320	
SM-07S	3	2538 - 29	02/24/87	--	8.1	0.11	0.11	0.010	0.0050	0.0020	0.0050	0.021	0.010	180	3.80	38	1.20	0.0050	85.0	2.40	5.90	25	580	50	240	
SM-08B	2	1298 - 28	12/17/86	--	9.0	0.13	0.13	0.03	0.0050	0.0020	0.0050	0.011	0.010	310	3.60	59	1.40	0.0050	120.0	3.00	4.30	37	830	32	320	
SM-08S	2	1298 - 29	12/17/86	--	9.0	0.21	0.19	0.02	0.0050	0.0020	0.0050	0.012	0.010	380	3.70	60	1.40	0.0050	110.0	2.60	4.10	36	860	33	320	
WILLAMETTE RIVER																										
SM-04	1	98424 - 4	08/21/86	7.4	7.0	--	--	0.010	0.0050	0.0020	0.0050	0.008	0.60	5	--	12	0.21	0.120	6.3	1.20	2.30	14	110	30	28	
SM-04	3	2538 - 9	02/23/87	--	6.1	0.010	0.010	0.010	0.0050	0.0020	0.0050	0.016	0.08 B	4	20.00	14	0.63	0.040	8.0	0.80	2.30	11	110	25	30	
SM-05	1	98424 - 5	08/21/86	8.1	6.8	--	--	0.010	0.0050	0.0020	0.0050	0.014	0.26 B	5	--	14	0.21	0.100	5.7	1.20	2.70	13	120	31	30	
SM-05	3	2538 - 8	02/23/87	--	5.9	0.010	0.010	0.010	0.0050	0.0020	0.0050	0.007	0.05 B	4	3.10	11	0.62	0.038	8.0	0.80	2.30	9	100	24	30	
SM-05-dup	1	98424 - 6	08/21/86	8.0	6.9	--	--	0.010	0.0050	0.0020	0.0050	0.011	0.18 B	4	--	12	0.22	0.100	6.0	1.20	2.60	13	110	30	26	
SM-05-dup	3	2538 - 7	02/23/87	--	5.8	0.010	0.010	0.010	0.0050	0.0020	0.0050	0.051	0.16 B	4	3.50	12	0.61	0.041	8.0	0.60	2.10	9	100	25	28	

U: following a number indicates concentration below detection limit. Value shown is detection limit.

dup: following a sample number indicates sample is a duplicate.

B: following a number indicates blank concentration within 10x sample result. See Appendix B Section 4.0 for explanation.

J: following a number indicates estimated concentration. See Appendix B Section 4.0 for explanation.

4.5.5 Contaminant Transport

4.5.5.1 Contaminant Sources

The primary contaminant source materials appear to contribute lead, zinc, possibly arsenic, chromium, and other materials to the ground water. Available data suggest that lead, zinc, arsenic and chromium are the contaminants of concern that have migrated in ground water. The mobility of lead, arsenic, and zinc are similar under conditions found at the site, although zinc may persist in ground water more than lead. Chromium mobility is enhanced by the increased solubility of the hexavalent species.

Two types of lead sources exist at the Gould site. The major source includes debris remaining from earlier lead recovery operations, including battery casings and parts and the smelter matte. Another source which may be significant is the lead incorporated in the subsurface near the industrial sources. This lead, sorbed on soil mineral phases or precipitated as oxides, hydroxides, or sulfate, may act as a source for lead in ground water after the primary (industrial) sources have been removed or stabilized. These secondary sources may arise in two ways; the sorption of dissolved lead onto clays and iron oxides in the soil, and as a chemical precipitate that forms where significant changes in ground-water chemistry are encountered.

The most important chemical change encountered in the ground-water system on (and near) the site is pH change. At the primary sources, the pH is generally quite low ($\text{pH} < 5$) because of the sulfuric acid from the scrapped batteries. The pH gradually increases away from the sources because of the buffering effect of reactions with natural soil minerals. The by-product debris from the air products operation nearby is a source of very high pH water. As pH increases, the solubility of lead in water decreases, accompanied by the precipitation of lead oxides and hydroxides. At very high pH ($\text{pH} > 11$), lead increases in solubility as stable hydroxy-complexes form (Schock and Gardels 1983). High pH values exist at the Liquid Air site as a result of alkaline wastes; however, associated elevated dissolved lead is not present.

4.5.5.2 Lead Solubility On Site

The amount of lead that can be dissolved in ground water is a function of temperature, pH, other dissolved species present, amount of available lead and contact time. Assuming temperatures to be constant, all these factors are significant with regard to lead solubility in ground water in the study area.

Theoretical maximum levels of dissolved lead, in thermodynamic equilibrium with an unlimiting source, can be estimated from studies done by the EPA (Davies and Everhard 1973) on lead equilibrium in "hard" water (Figure 4.5-21). These estimates are a function of pH only, as time and lead were not limiting, and other interference such as cation exchange and adsorption were not present in the study.

Typically, the dissolved lead concentration observed in the ground water on site were much less than the theoretical maximums. The relationship of pH to the ratio of observed dissolved lead (for samples with dissolved lead above detection limits) to theoretical maximum dissolved lead is shown on Figure 4.5-22. The graph shows a general trend that indicates a low observed solubility ratio when theoretical solubility is high (at high and low pHs), and a high ratio (tending towards 1.0) when the theoretical solubility is low (around neutral pHs).

The solubility relationship may be a function of limited lead available for dissolution. This contention is supported by the observation that if the water samples from wells W-2D and W-7D, which exhibit low pHs in an environment of more readily available lead (beneath the battery casing piles) are treated separately, the general relationship already described becomes clearer and a separate, distinct solubility relationship exists in these wells where lead is more available (i.e., as pH decreases, lead solubility increases).

Figure 4.5-22 provides a means to estimate expected solubilities on site given the field conditions encountered, as a function of pH and theoretical maximum dissolved lead.

The reasons for the observed condition are probably complex. At high pHs, observed in the vicinity of wells W-15 and W-16, the impact of

alkaline material from Schnitzer Liquid/Air, although increasing pH and subsequent solubility potential, may also provide an environment of increased exchange capacity and subsequent decrease in dissolved lead. Lead may also exist in more or less soluble forms (depending on pH and other dissolved species) with respect to location, waste type and chemical environment. High TOC may also provide a matrix that can complex with and remove dissolved lead.

The subsurface chemistry and physical conditions are sufficiently varied on site to create a situation where lead solubility potential can also be highly variable. However, given the observed solubilities, pH appears to be a fairly good indicator of the potential fraction of theoretical values that may become dissolved, especially if the conditions at wells W-7D and W-2D are regarded as a separate case. Some previous studies have indicated that lead (as well as other metals) migration in aquifers of a similar or higher permeability than encountered here, is highly dependent on pH (Haji-Djafari et al. 1981).

Figure 4.5-22 indicates that at approximately pH 6.0, the condition at wells W-7D and W-2D becomes similar to the general site condition with respect to lead solubility. Since acids are no longer being dumped into East Doane Lake, we would expect that pHs would increase from inflow of more neutral ground water at W-7D and W-2D until pH levels at that site are similar to pH levels recorded upgradient or in the fill. Therefore, it is assumed that present conditions represent the worst case with respect to future possible dissolved lead transport.

4.5.5.3 Particulate Transport

In addition to transport of lead and other contaminants in a dissolved state, it is possible that contaminants can be transported in an adsorbed or complexed state, along with transport of fine colloidal sediments in ground water. Chemicals strongly adsorbed to colloidal surface may move with the carrier material to deeper layers of the unsaturated zone during subsurface flow events or laterally in the course of horizontal ground-water flow. The characteristics of the subsurface flow and the characteristics of the porous media both influence

the potential for such movement. If the porosity of the media is such that a sufficient number of pores are larger than the particle being transported, the pores are sufficiently interconnected and flow velocities are high enough, colloidal soil particles can be transported significant distances.

Results of previous studies concerned with this transport mechanism by Vinten et al. (1983) have shown that in coarse sands, up to 50 percent of some contaminants have been transported a distance of 5 cm or more by particulate transport. In sandy loams, they found up to 20 percent transport greater than 5 cm and in silt loams, less than 5 percent of the contaminants studied were transported greater than 5 cm via particulate transport.

The result of the above study indicates that particulate transport of sorbed contaminants may be an important mechanism for short distance contaminant transport in soils with permeabilities similar to those found in sands and coarse sands. The soils in the study area exhibit generally low permeabilities except in isolated, non-continuous pockets in the fill that exhibit permeabilities on the order of a coarse sand. Thus, particulate transport of lead or other contaminants on site may be important in localized areas; however, in general, it is not considered as an important potential contaminant transport mechanism on site.

4.5.5.4 Retardation

The factors that can cause lead and other contaminants to move more slowly than ground water include precipitation and sorption. The pH of ground water is the primary variable that affects the solubility of metals, although oxidation potential, salinity and presence of various anions and complexing agents may be significant. The specific solid lead compounds that determine the stability are determined by ground-water conditions. Oxides, hydroxides, sulfates, and mixed species are expected to be important at various areas in the subsurface of the site.

These solubilities are theoretical, and generally represent upper limits for dissolved lead. Kinetic effects and sorption will tend to

decrease the lead in solution with respect to the solubility limits. Some previous studies have indicated that lead has a high attenuation potential related to chemical processes within in-situ aquifer materials. This high attenuation often overshadows physical transport mechanisms, resulting in low advancement of lead within the aquifer (Haji-DjaFari et al. 1981).

4.5.5.5 Contaminant Transport Velocity

The average linear velocity of a contaminant plume within the fill water-bearing unit is defined here by the following relationship:

$$V_c = D / (t_s - t_c)$$

where:

V_c	= average linear plume velocity	(length)
D	= distance from source to the observation point	(length)
t_s	= time contaminant source began	(time)
t_c	= time of arrival at the observation point of $C/Co = 0.5$	(time)
C	= concentration observed	(mg/l)
Co	= steady state concentration	(mg/l)

The range of plume velocities are estimated from the sulfate (SO_4) concentrations in the ground water at wells W-7S and W-11S. Both wells appeared to have reached steady state concentrations of 300 to 310 and 30 to 36 milligrams per liter (mg/l) respectively, as measured during this investigation. Sulfate is selected because it is the most mobile of the contaminants investigated. Plume velocities for other less mobile contaminants would be lower.

Sensitivity calculations were performed to assess the uncertainty of the input parameters. The uncertainties are:

1. Exact time of arrival of the $C/Co = 0.5$ concentration at the observation point; and
2. Travel time within the vadose zone.

The time of arrival of the $C/Co = 0.5$ concentration is sometime between 1949 when disposal of battery wastes began and 1981 when disposal of waste was suspended. Within this 32-year period, the sulfate

from the source arrived at wells W-7S and W-11S. Thus, for the purpose of estimating the approximate order of magnitude of the contaminant transport velocity, an arrival time range of 1 to 30 years is assumed.

Based on this assumption and the distance between wells W-7S and W-11S, the estimated range of plume velocity for sulfate is 0.07 to 2.2 feet per day. This estimate is assumed to be worst-case in that retardation mechanisms of the contaminants are ignored.

4.5.5.6 Prediction of Lead Migration

Ground-water transport is one mechanism by which dissolved lead could migrate off site. The critical factors in estimating lead migration rates are lead concentrations in the ground water, the rate at which ground water moves, adsorption, precipitation, and dilution. Each of these factors can be expressed with varying degrees of sophistication and accuracy.

The rate of lead migration off site is estimated from the following relationship:

$$Q_1 = (C)(V)$$

when Q_1 = lead migration rate

C = dissolved lead concentrations

V = ground-water flow rate

The observed lead concentration in ground water of the fill is 0.01 to 0.02 ppm at the boundaries of the site. The off-site lateral ground-water flow rate from the fill is estimated in Section 4.4.3.6 to be 229,000 ft³/yr. This yields a potential dissolved lead migration rate of 0.15 lb/yr to 0.30 lb/yr.

The observed lead concentration in the ground water of the upper and lower alluvium is 0.01 to 0.02 ppm at the boundaries of the site. The off-site lateral ground-water flow rate from the alluvial water-bearing units is estimated in Section 4.4.3.6 to be 226,000 ft³/yr. This also yields a potential dissolved lead migration rate of 0.15 lb/yr to 0.30 lb/yr.

The total lateral dissolved lead migration rate is therefore estimated at approximately 0.3 lb/yr to 0.6 lb/yr. This estimate is conservative because retardation effects of adsorption and precipitation, which would reduce the migration rate, are ignored. Evidence of past groundwater migration off site at significantly lower pH values is not clear. Given the ion exchange capacity of the soil, and the total recoverable lead levels measured, it seems likely that lead has been adsorbed or complexed on site, rather than transported in the dissolved phase off site. If present conditions are indicative of past levels of dissolved lead concentrations, a total of approximately 10 to 20 pounds of lead may have migrated off site over the past 32 years (1949 to 1981).

The observed lead concentration in the basalt is less than or equal to 0.01 ppm. The ground-water flow rate from the alluvium into the basalt is estimated in Section 4.4.3.6 to be 5×10^6 ft³/yr. This yields a potential dissolved lead migration of 3 lb/yr. This estimate probably overstates the actual migration rate because of the upward gradient observed between the basalt and the alluvial aquifers downgradient of well W-6.

An additional mechanism of dissolved lead transport is via surface water discharge out of East Doane Lake. The lead concentrations are probably insufficient to cause detectable water quality changes in the Willamette River.

The sulfate and lead plume maps indicate that lead has possibly migrated at least as far as well PP-11 and W-10D in the past (reflected in elevated total recoverable lead or elevated sulfate and dissolved lead above 0.02 ppm). This is approximately 1,000 feet from an assumed source near well W-2. The ground-water and contaminant velocity estimates both indicate that this distance is well within expected upper limits of possible transport distances over the 32-year period. Since dissolved lead levels at these locations are low, either the lead migration has been retarded and lead has been removed from solution, or a more concentrated plume of lead (with associated low pH) that once existed has been attenuated by any number of mechanisms (dilution, adsorption, precipitation, oxidation, or complexation). It appears that present con-

ditions will not become worse, with respect to dissolved metal concentrations, because contaminant deposition has ceased. However, if acids were reintroduced to the ground water, possible remobilization of lead could occur.

Exposure risks from ground-water contamination on site seems to be confined to lead, arsenic, and chromium. These contaminants exist primarily in the region around East Doane Lake, extending downgradient to well PP-11. The possibility of migration of these contaminants off site is considered to be present primarily in the dissolved state. Current levels of dissolved lead, arsenic, and chromium at the most downgradient wells (W-11, W-10, and PP-11) indicate that no concentration above MCLs exists. The maximum dissolved lead concentration observed at these wells was 0.03 ppm and the average less than 0.02 ppm. The maximum dissolved levels of arsenic and chromium at these wells was less than detection limits (.005 ppm).

5.0 AIR INVESTIGATION

5.1 INTRODUCTION AND BACKGROUND

As part of the Remedial Investigation/Feasibility Study Work Plan for the property currently owned by Gould, Inc., an air monitoring investigation for airborne lead was conducted at the site. Operations at the site, a former battery recycling facility and secondary lead smelter, ceased in August 1981. However, the suspected presence of lead in shredded battery casing piles on the site and in contaminated surface soils around the site mandated that the airborne particulate pathway be examined.

Air quality monitoring conducted by the Oregon Department of Environmental Quality (DEQ) from June through September 1981 at locations around (but not on) the Gould property indicated occasional airborne lead levels in excess of both the Federal National Ambient Air Quality Standards and the Oregon State Ambient Air Quality Standard for Lead (see Table 5.1-1). Monitoring by EPA Region X and Dames & Moore on Gould property during 1982 also showed high airborne lead levels (see Table 5.1-2). The highest concentrations measured by EPA were within a few feet of the piles of battery casings. Both the Federal and Oregon state standard for lead are 1.5 micrograms per cubic meter of air ($\mu\text{g}/\text{m}^3$) expressed as an arithmetic mean over a calendar quarter (3 months).

This section documents the resumption of air monitoring at the site in conjunction with the other environmental investigations mandated by EPA's Administrative Order on Consent executed August 29, 1985. Air quality data are evaluated to determine whether off-site migration of contaminants is presently occurring via the airborne particulate pathway.

The air quality investigation report is divided into several major sections. Section 5.2 describes monitoring location selection, monitoring methodology and equipment, and operation of the monitoring system.

TABLE 5.1-1

SUMMARY OF AIRBORNE LEAD CONCENTRATIONS
MONITORED BY DEQ

Date (1981)	Site (values in ug/m ³)		
	NW#1	NW#2	NW#3
June 15	0.49	3.6	3.1
21	0.29	1.43	0.51
27	0.66	0.51	0.77
July 3	0.79	0.30	0.51
9	1.37	9.4	2.54
15	13.2	1.58	3.4
21	1.50	1.15	5.7
27	15.5	1.22	2.54
August 2	2.28	0.58	1.02
8	15.3	1.94	1.79
14	1.26	0.80	2.34
20	0.75	1.93	0.87
26	-	2.89	0.85
September 1	-	0.87	0.44
3	3.5	-	-
7	0.55	1.32	0.48
13	0.98	0.36	0.56
19	2.09	0.39	0.28
25	0.37	3.2	0.37
July to September Quarterly Average	4.2	1.9	1.6

Source: Oregon DEQ 1981

TABLE 5.1-2

SUMMARY OF AIRBORNE LEAD CONCENTRATIONS
MONITORED BY DAMES & MOORE AND EPA REGION X

Date (1982)	Site (values in ug/m ³)					
	D&M#1	D&M#2	D&M#3	EPA#1	EPA#2	EPA#3
August 20	0.26	0.38	0.28			
21	0.26	0.39	1.06			
22	0.38	0.40	1.60			
23	0.39	0.41	0.47	4.4	11.7	150.0

Source: U.S. EPA 1982

It also describes training requirements for the site operator, data processing and reporting, and meteorological data collection. Section 5.3 describes the results of the investigation. Section 5.4 describes the potential risks associated with sources of airborne lead in the study area. Section 5.5 discusses the potential for migration of lead through the airborne pathway. Details of the air monitoring and sampling program, including monitor siting, equipment specifications and operating procedures, are presented in Appendices A and B.

5.2 SAMPLING PROGRAM

The ambient air monitoring program described in this section employed air sampling equipment and operating procedures with a proven record of high quality, accuracy and reliability. All data were collected from instruments having an EPA designation as a Reference Method. The samplers were operated and calibrated following the guidelines of EPA's Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD), dated November 1980. Quality assurance functions were performed following Title 40 of the Code of Federal Regulations, Part 58, Appendix B, Quality Assurance Requirements for PSD Air Monitoring. A detailed description of the sampling methods are presented in Appendix A, Section A1.7 and Appendix B, Section B3.0.

Figure 5.2-1 shows the locations of the air monitoring instruments, samplers S-1, S-1A, S-2 and S-3. The primary objective in choosing these locations was to maintain consistency with the earlier air monitoring studies conducted by DEQ. Samplers S-1, S-1A, and S-3 are at the same locations used in previous air monitoring events at the property. Sampler S-2 has been relocated north-northeast of the original monitoring site to improve the likelihood of discriminating between the onsite and background components of lead concentrations. Samplers S-2 and S-3 are located nearest the battery casing piles, which would increase their expected airborne lead concentrations. Sampler S-3 is also aligned with the battery casing piles along a main wind flow direction vector (northwest to southeast).

The air monitoring program was required to sample not only on the EPA national six-day monitoring schedule, but also anytime there were dust-producing remedial investigation activities on site. As a result of this requirement, there are more air monitoring data available than would normally have been obtained. To calculate monthly and quarterly averages in an unbiased manner, a six-day cellular averaging method was used. (See Appendix A, Section A1.7 for details of the method.) Samplers S-1 and S-1A were collocated at the same site to allow development of quality control statistics.

The onsite system operator, Mr. Gene Moore of Gould Inc., normally inspected the high volume (HIVOL) monitors at least once every 6 days in accordance with the EPA national schedule for high volume monitoring. In addition, any time that activities involving drilling, soil sampling or digging of test pits occurred on site, the monitoring system was operated. Therefore, the monitors were inspected more frequently than once every 6 days.

Since Mr. Moore's office is located on site, he was generally available during normal business hours throughout the period when air investigations were conducted. His responsibilities as system operator included the following:

- ° Changing filter media after each sampling event,
- ° Performing site checks and maintaining site logs,
- ° Maintaining and troubleshooting equipment, and
- ° Performing routine calibration of HIVOL monitoring equipment after equipment repair.

Project technical assistance was provided by Dames & Moore. The technical assistance personnel were not involved in the day-to-day operational activities of the monitoring project, but provided assistance as requested by the onsite system operator. Since the technical assistance personnel were not involved in daily project activities, these personnel were able to conduct the required system and performance audits. These personnel were used for the following activities:

- ° Installing monitoring site and equipment,
- ° Training onsite system operators,
- ° Preparing summary data reports,
- ° Changing chart paper on the MRI mechanical weather station,
- ° Conducting system and performance audits, and
- ° Assisting in repairing equipment (as necessary).

The onsite system operator was instructed in proper HIVOL monitor operations, upkeep, filter handling procedures, recordkeeping and repairs by a qualified Dames & Moore instrument technician at the time of sampler installation in April 1986. A Dames & Moore technician, Mr. John Cooper, was designated as a contact for the onsite system operator in case of unusual problems or questions.

5.3 INVESTIGATION RESULTS

5.3.1 Concentrations of Airborne Lead

Airborne lead concentrations measured as part of the RI/FS study conducted by Dames & Moore are shown in Table 5.3-1. The highest daily value observed during the sampling period was 5.20 ug/m³ at sampler S-3 on August 25, 1986. This coincided with observed site activity. Specifically, workers from a firm acquiring the inoperative battery casing separating machine were steam cleaning and decontaminating the equipment

TABLE 5.3-1
AIRBORNE LEAD CONCENTRATIONS
DAILY AVERAGES

Sheet 1 of 3

Daily Averages (ug/m ³)					
Date	S-1 Sampler	S-1A Sampler	S-2 Sampler	S-3 Sampler	Site Activity*
04-16-86	0.09	0.06 ^a	0.04	void ^b	
04-20-86	0.10	0.19	0.14	0.15	
04-26-86	0.10	0.04	0.09	0.09	
05-02-86	0.05	0.04	0.09	0.10	
05-08-86	0.10	0.09	0.09	0.09	
05-14-86	0.05	0.05	0.05	0.05	
05-20-86	0.10	0.09	0.09	0.10	
05-26-86	0.10	0.09	0.10 ^a	0.15	
05-29-86	0.34	0.33	0.14	1.10 ^a	
06-01-86	0.19	0.17	0.10	0.42	
06-02-86	0.05	0.13 ^a	0.17 ^a	0.34 ^a	4
06-03-86	0.10	0.08	0.10	0.11 ^a	4
06-04-86	0.05	0.04	0.15	0.17	4
06-05-86	0.10	0.04	0.11 ^a	0.05	4
06-07-86	0.14	0.12	0.14	1.25	4
06-10-86	0.44	--	0.62	0.30	4
06-11-86	0.20	--	0.20	0.21	4
06-13-86	0.09	0.08	0.21	0.22	
06-19-86	0.05	0.04	0.05	0.10	
06-25-86	0.19	0.16	0.23	0.09	
07-01-86	0.10	0.12	0.15	0.15	
07-07-86	0.05	0.08	0.09	0.05	4
07-13-86	0.05	0.08	0.13	0.15	1
07-15-86	0.05	--	0.23	0.24	4
07-16-86	0.04	--	0.08	0.09	4
07-17-86	0.09	--	0.09	0.14	4
07-18-86	0.09	--	0.09	0.09	4
07-19-86	0.09	0.14	0.22	0.23	
07-22-86	0.27	--	0.75	0.22	1
07-23-86	0.39	--	0.26	0.15 ^a	1
07-24-86	0.45	--	0.44	0.05 ^a	1
07-25-86	0.81	0.67	0.84	0.21	1
07-28-86	0.33	--	0.39	0.33	1
07-29-86	0.61	--	0.88	0.37	1
07-30-86	0.61	--	0.86	0.81	1
07-31-86	0.53	0.51	0.61	0.44	1
08-01-86	1.48 ^c	--	1.38 ^c	1.11 ^c	1
08-04-86	0.63	--	0.67	0.88	1
08-05-86	1.04	--	1.40	0.54	1
08-06-86	0.84	0.94	0.74	0.58	1
08-07-86	0.80	--	0.63	0.43	1,3,6

TABLE 5.3-1 (Continued)

Sheet 2 of 3

Daily Averages (ug/m ³)					
Date	S-1 Sampler	S-1A Sampler	S-2 Sampler	S-3 Sampler	Site Activity*
08-08-86	0.71	--	0.40	0.70	1
08-11-86	0.27	--	0.17	1.12	1
08-12-86	0.26	0.24	0.18	0.42	1
08-13-86	0.32	--	0.26	0.37	1,3
08-14-86	0.65	--	0.96	1.17	1
08-15-86	0.55	--	0.43	0.13	1
08-18-86	0.48	0.57	0.39	0.53	3
08-22-86	0.46	--	0.52	1.59	3,5
08-24-86	0.15	0.14	0.21	0.60	3
08-25-86	0.94	--	1.37	5.20	3,7
08-26-86	0.53	--	0.48	1.42	3
08-27-86	0.60	--	0.91	1.48	3
08-30-86	0.04	0.08	0.04	0.08	3
09-02-86	0.42	--	0.17	0.24	2,3
09-03-86	0.41	--	0.35	0.60	2,3
09-05-86	0.33	0.27	0.49	0.44	3,6,7
09-11-86	0.27	0.27	0.34	1.16	3,6,7
09-12-86	0.23	--	2.03	1.56	3
09-17-86	0.05	0.04	0.09	0.21	3
09-23-86	0.09	0.08	0.09	0.12	6,7
09-24-86	void ^d	--	0.25	0.08	7
09-29-86	0.21	0.20	0.09	0.17	3
10-05-86	0.08	0.08	0.09	0.07	
10-11-86	0.20	0.15	1.07	0.07	
10-17-86	0.17	0.15	0.17	0.15	
10-23-86	0.24	0.23	0.26	0.29	6
10-29-86	0.08	0.08	0.13	0.07	
11-04-86	0.20	0.19	0.21	0.32	
11-10-86	0.16	0.15	0.14	0.15	
11-16-86	0.04	0.04	void ^d	0.04	
11-22-86	0.04	0.04	0.04	0.03	
11-25-86	0.12	--	0.08	0.11	1
11-28-86	0.08	0.04	0.04	0.07	1
12-01-86	0.12	--	0.12	0.10	1,6
12-02-86	0.12	--	0.12	0.07	1
12-03-86	0.12	--	0.16	0.10	1
12-04-86	0.12	0.11	0.16	0.11	1,3
12-05-86	0.15	--	0.16	0.14	1
12-08-86	0.08	--	0.08	0.07	1,6
12-09-86	0.11	--	0.12	0.07	1,6
12-10-86	0.15	0.14	0.12	0.08 ^a	1,3
12-11-86	0.19	--	0.24	0.17	1,3

TABLE 5.3-1 (Concluded)

Sheet 3 of 3

Date	Daily Averages (ug/m ³)				Site Activity*
	S-1 Sampler	S-1A Sampler	S-2 Sampler	S-3 Sampler	
12-12-86	0.12	--	0.12	0.10	1,3
12-15-86	0.20	--	0.16	0.17	1,3
12-16-86	0.25	0.23	0.24	0.20	1,3,6
12-17-86	0.35	--	0.52	0.31	1,3,5
12-18-86	0.11	--	0.24	0.14	1,3
12-19-86	0.08	--	0.08	0.08	1,3
12-22-86	0.08	0.08	0.12	0.07	3
12-23-86	0.04	--	0.08	void ^d	3
12-28-86	0.04	0.04	0.08	0.03	3
1-5-87	0.16	--	0.12	0.1	1,4
1-6-87	0.12	--	0.12	0.1	1,4
1-7-87	0.39 ^a	--	0.12	0.1	1,2

*Site Activity Code

- 1 - Soil bearing/well installation
- 2 - Test pits/battery casing and matte sampling
- 3 - Well development/ground-water sampling
- 4 - Surface soil sampling
- 5 - Surface water/sediment sampling
- 6 - Water level measurements
- 7 - Other activities

^a Void by EPA standards--Sampler run time was less than 23 hours, but at least 12 hours.

^b Dixon chart was questionable.

^c Conditions included drilling on Rhone Poulenc and ESCO, plus strong winds.

^d Sampler run time was less than 12 hours.

on the Gould property prior to moving the equipment from the site. On that day, Dames & Moore personnel observed clouds of airborne particulate from the cleaning operations move over the operating sampler S-3. This would account for the high concentrations of airborne lead recorded on that date. The cleaning operations took place near the battery casing piles, northwest of sampler S-3 (along a prevailing wind direction) approximately 100 yards away from the sampler.

The highest monthly average airborne lead concentration observed (as shown in Table 5.3-2) was 0.94 ug/m^3 , observed again at sampler S-3 in August, and largely attributable to the August 25, 1986 equipment cleaning incident. This monthly average is well below the federal and state ambient air standard for lead of 1.5 ug/m^3 on a quarterly basis. The average readings from other samplers during August 1986 were similarly higher than averages during other months, confirming the expected trend of higher airborne particulate levels during the dry summer months. Dry weather along with the remedial investigation activities and equipment cleaning (i.e., more dust-generating activities occurring around the site) may account for the significantly higher values observed during this time period.

The highest quarterly average airborne lead concentration of 0.55 ug/m^3 (as shown in Table 5.3-2) was observed at sampler S-3 during the July to September 1986 quarter. This concentration is just over one third of the allowable federal and state ambient air quality standards of 1.5 ug/m^3 as a arithmetic quarterly average. This quarter was similarly high for all monitors, again confirming the trend for higher airborne particulate levels during the dry summer months. The second highest quarterly average, 0.41 ug/m^3 , was observed at sampler S-2. Both samplers S-2 and S-3 are the closest to the battery casing piles and could be expected to show the highest lead levels, if the casing piles are the main source of airborne lead.

TABLE 5.3-2

AIRBORNE LEAD CONCENTRATIONS
MONTHLY AND QUARTERLY AVERAGES

Date (1986)	Averages (ug/m ³)			
	Sampler S-1	Sampler S-1A	Sampler S-2	Sampler S-3
<u>Monthly Arithmetic Averages</u>				
April ^a	0.10	0.10	0.09	0.08
May	0.08	0.07	0.08	0.10
June	0.16	0.12	0.19	0.36
July	0.25	0.27	0.33	0.28
August	0.51	0.39	0.54	0.94
September	0.19	0.17	0.37	0.45
October	0.15	0.14	0.34	0.13
November	0.13	0.09	0.10	0.14
December	0.12	0.12	0.15	0.10
<u>Quarterly Arithmetic Averages</u>				
April to June	0.11	0.10	0.12	0.18
July to September	0.32	0.28	0.41	0.56
October to December	0.13	0.12	0.20	0.12

^a April averages include only 3 of the 5 EPA National Schedule weeks.

5.3.2 Meteorology

Wind-sensing instrumentation was located at site M-1, as shown on Figure 5.2-1. This monitoring location was established by Rhone-Poulenc during the early 1970's. The instrument was still in place, although not operational at the time remedial investigation activities at the NL/Gould site was being planned. After obtaining permission from Rhone-Poulenc to use the instrument, it was fully reconditioned, recalibrated and placed in operation on August 11, 1986. This site provided reliable data for the remainder of the onsite remedial investigation.

Historical meteorological monitoring data for the Rhone-Poulenc site could not be located. Therefore, historical meteorological data for a site at the Standard Oil tank farm (approximately one-quarter mile east of the Gould site) was obtained for the period from February 5, 1977 through August 29, 1980. This site was operated by DEQ using the same type of meteorological sensor as that operated at the Rhone-Poulenc site.

Wind data collected at the Rhone-Poulenc site during the period from August 11, 1986 through November 30, 1986 is presented in a Wind Frequency Distribution Table (Table 5.3-3) and a "wind rose" (Figure 5.3-1). Comparative data for the Standard Oil site east of the Gould property for the period from February 5, 1977 to August 29, 1980 is shown in Tables 5.3-4 to 5.3-6 and in Figures 5.3-2 through 5.3-4. The data suggest that wind patterns during the period from August through November 1986 were basically similar to the same periods in 1977 and 1979 (insufficient data for 1978), and very similar to the entire 1977 to 1980 period. This would indicate that, from a meteorological standpoint, air quality data collected during 1986 is generally representative of normal weather patterns. The data indicate a high percentage of calm periods, from 15 to 20 percent of the time. There is also a pronounced tendency for wind channelling along the northwest to southeast directions. This is consistent with local topography, since there is a ridge to the southwest of the site paralleling the Willamette River. Winds exceeding 4.0 meters per second are infrequent, occurring generally less than eight percent of the time.

TABLE 5.3-3

WIND FREQUENCY DISTRIBUTION
RHONE-POULENC SITE
AUG. 11, 1986 TO NOV. 30, 1986

OBSERVATIONS PER DAY - 24
OBSERVATIONS PER INPUT FIELD - 1
TIME CORRECTION IN HOURS - .00
WIND SPEED INPUT IN MPS
WIND DIRECTION INPUT IN DEGREES

RHONE-POULENC SITE

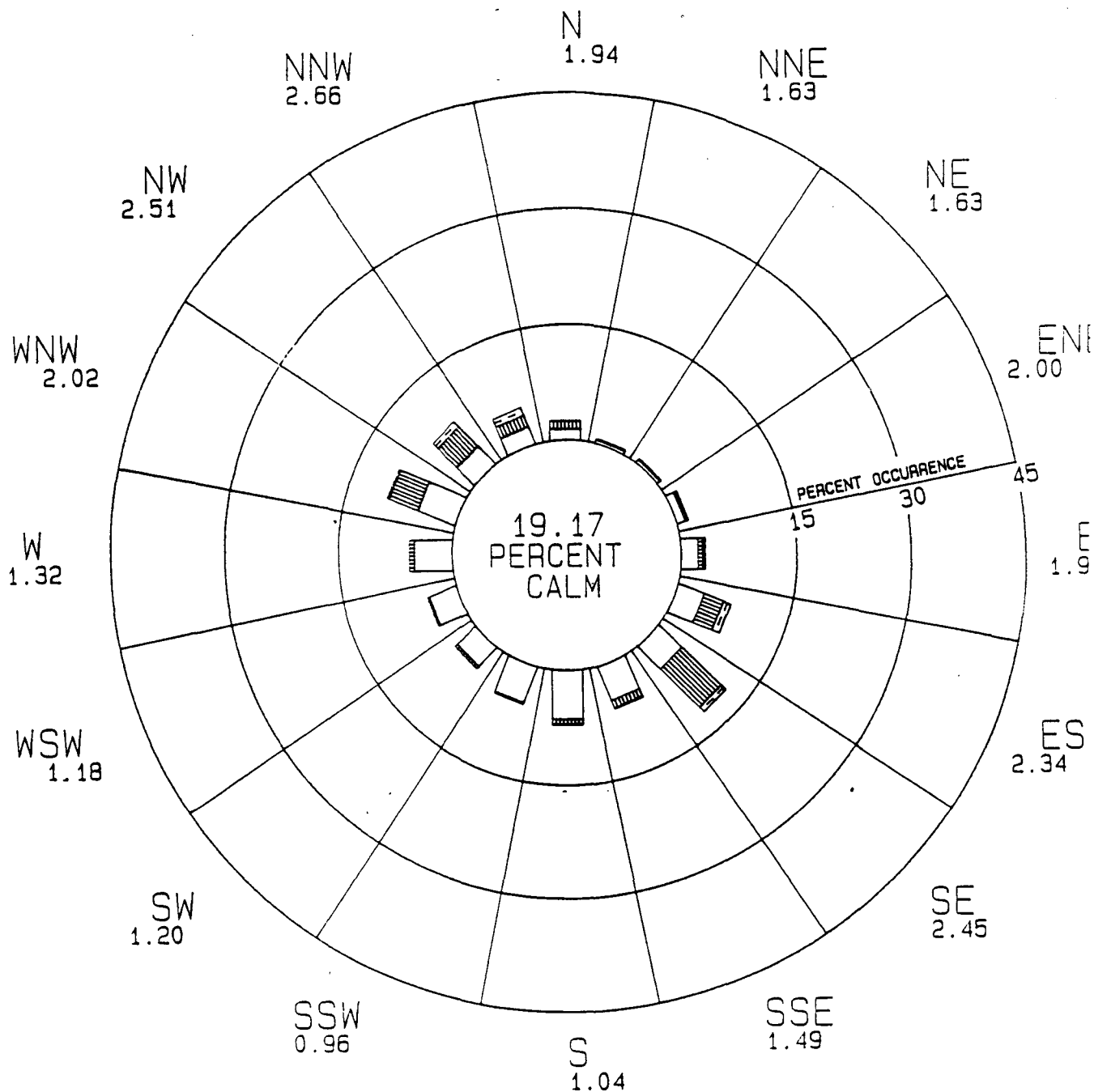
NL INDUSTRIES/GOULD RI/FS
WIND FREQUENCY DISTRIBUTION ANALYSIS

DATA PERIOD - AUG 11, 1986 THROUGH NOV 30, 1986
MONTHS CONSIDERED - AUG THROUGH NOV
HOURS CONSIDERED - 0 TO 2400
ANEMOMETER HEIGHT - 10 METERS

WIND FREQUENCY DISTRIBUTION
FREQUENCY IN PERCENT
OF TOTAL OBSERVATIONS

WIND SECTOR	WIND SPEED CLASS (MPS)					TOTAL	MEAN SPEED
	.46 TO 2.00	2.01 TO 4.00	4.01 TO 8.00	8.01 TO 12.00	GREATER THAN 12.00		
NNE	.41	.11	.00	.00	.00	.52	1.63
NE	.41	.11	.00	.00	.00	.52	1.63
ENE	1.01	.34	.07	.00	.00	1.42	2.00
E	2.16	.60	.30	.00	.00	3.06	1.93
ESE	3.51	2.72	1.01	.00	.00	7.24	2.34
SE	4.14	7.12	.82	.00	.00	12.09	2.45
SSE	4.66	1.12	.04	.00	.00	5.82	1.49
S	6.34	.67	.04	.00	.00	7.05	1.04
SSW	4.92	.19	.00	.00	.00	5.11	.96
SW	3.32	.41	.00	.00	.00	3.73	1.20
WSW	3.77	.26	.00	.00	.00	4.03	1.18
W	4.96	.67	.00	.00	.00	5.63	1.32
WNW	5.15	4.14	.26	.00	.00	9.55	2.02
NW	3.13	3.58	.90	.00	.00	7.61	2.51
NNW	2.28	1.64	1.08	.00	.00	5.00	2.66
N	1.34	1.12	.00	.00	.00	2.46	1.94
CALM						19.17	
TOTAL	51.51	24.80	4.51	.00	.00	100.00	1.51

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID OBSERVATIONS = 2681



11831-034

NL IND, INC./GOULD, INC.
 REMEDIAL INVESTIGATION
 WIND FREQUENCY DISTRIBUTION
 RHONE-POULENC SITE
 AUG. 11, 1986 TO NOV. 30, 1986
 FIG. 5.3-1 DAMES & MOO

TABLE 5.3-4

WIND FREQUENCY DISTRIBUTION
STANDARD OIL SITE
AUG. 6, 1979 TO NOV. 30, 1979

OBSERVATIONS PER DAY - 24
OBSERVATIONS PER INPUT FIELD - 1
TIME CORRECTION IN HOURS - .00
WIND SPEED INPUT IN MPS
WIND DIRECTION INPUT IN DEGREES

STANDARD OIL
OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
WIND FREQUENCY DISTRIBUTION ANALYSIS

DATA PERIOD - AUG 6, 1979 THROUGH NOV 30, 1979
MONTHS CONSIDERED - AUG THROUGH NOV
HOURS CONSIDERED - 0 TO 2400
ANEMOMETER HEIGHT - 10 METERS

WIND FREQUENCY DISTRIBUTION
FREQUENCY IN PERCENT
OF TOTAL OBSERVATIONS

WIND SECTOR	WIND SPEED CLASS (MPS)					TOTAL	MEAN SPEED
	.46 TO 2.00	2.01 TO 4.00	4.01 TO 8.00	8.01 TO 12.00	GREATER. THAN 12.00		
NNE	1.12	.15	.00	.00	.00	1.27	1.07
NE	1.61	.00	.00	.00	.00	1.61	.90
ENE	1.27	.19	.05	.00	.00	1.51	1.44
E	.93	.44	1.07	.00	.00	2.43	3.25
ESE	1.27	1.22	2.04	.00	.00	4.53	3.69
SE	3.85	4.92	3.65	.00	.00	12.41	3.02
SSE	4.72	3.26	.88	.00	.00	8.86	2.28
S	3.21	.19	.00	.00	.00	3.41	1.15
SSW	2.09	.19	.00	.00	.00	2.29	1.09
SW	2.63	.34	.00	.00	.00	2.97	1.18
WSW	8.13	.34	.00	.00	.00	3.47	1.06
W	23.03	2.53	.00	.00	.00	25.56	1.38
WNW	5.16	.88	.00	.00	.00	6.04	1.48
NW	3.55	2.39	.10	.00	.00	6.04	1.94
NNW	1.56	2.63	.29	.00	.00	4.48	2.55
N	.93	1.07	.00	.00	.00	2.00	2.08
CALM						6.13	
TOTAL	65.04	20.74	8.08	.00	.00	100.00	1.78

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 298
NUMBER OF VALID OBSERVATIONS = 2054

TABLE 5.3-5

WIND FREQUENCY DISTRIBUTION
STANDARD OIL SITE
AUG. 1, 1977 TO NOV. 30, 1977

OBSERVATIONS PER DAY - 24
OBSERVATIONS PER INPUT FIELD - 1
TIME CORRECTION IN HOURS - .00
WIND SPEED INPUT IN MPS
WIND DIRECTION INPUT IN DEGREES

STANDARD OIL
OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
WIND FREQUENCY DISTRIBUTION ANALYSIS

DATA PERIOD - AUG 1, 1977 THROUGH NOV 30, 1977
MONTHS CONSIDERED - AUG THROUGH NOV
HOURS CONSIDERED - 0 TO 2400
ANEMOMETER HEIGHT - 10 METERS

WIND FREQUENCY DISTRIBUTION
FREQUENCY IN PERCENT
OF TOTAL OBSERVATIONS

WIND SECTOR	WIND SPEED CLASS (MPS)					TOTAL	MEAN SPEED
	.46 TO 2.00	2.01 TO 4.00	4.01 TO 8.00	8.01 TO 12.00	GREATER THAN 12.00		
NNE	.65	.00	.00	.00	.00	.65	1.03
NE	.00	.00	.00	.00	.00	.00	.00
ENE	.23	.00	.00	.00	.00	.23	1.52
E	.00	.46	.32	.00	.00	.79	3.66
ESE	.37	.79	.28	.00	.00	1.43	2.89
SE	1.80	1.11	.00	.00	.00	2.91	1.87
SSE	2.77	.97	.00	.00	.00	3.74	1.55
S	11.56	.65	.00	.00	.00	12.21	1.24
SSW	6.66	.18	.00	.00	.00	6.84	.88
SW	6.06	.18	.00	.00	.00	6.24	.88
WSW	9.66	.92	.00	.00	.00	10.59	1.14
W	7.77	1.43	.00	.00	.00	9.20	1.36
WNW	6.33	1.57	.00	.00	.00	7.91	1.55
NW	4.58	2.77	.28	.00	.00	7.63	1.93
NNW	3.84	2.82	1.02	.00	.00	7.67	2.29
N	3.65	.69	.00	.00	.00	4.35	1.32
CALM						17.61	
TOTAL	65.93	14.56	1.90	.00	.00	100.00	1.21

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 141
NUMBER OF VALID OBSERVATIONS = 2163

TABLE 5.3-6

WIND FREQUENCY DISTRIBUTION
STANDARD OIL SITE
FEB. 5, 1977 TO AUG. 29, 1980

OBSERVATIONS PER DAY - 24
OBSERVATIONS PER INPUT FIELD - 1
TIME CORRECTION IN HOURS - .00
WIND SPEED INPUT IN MPS
WIND DIRECTION INPUT IN DEGREES

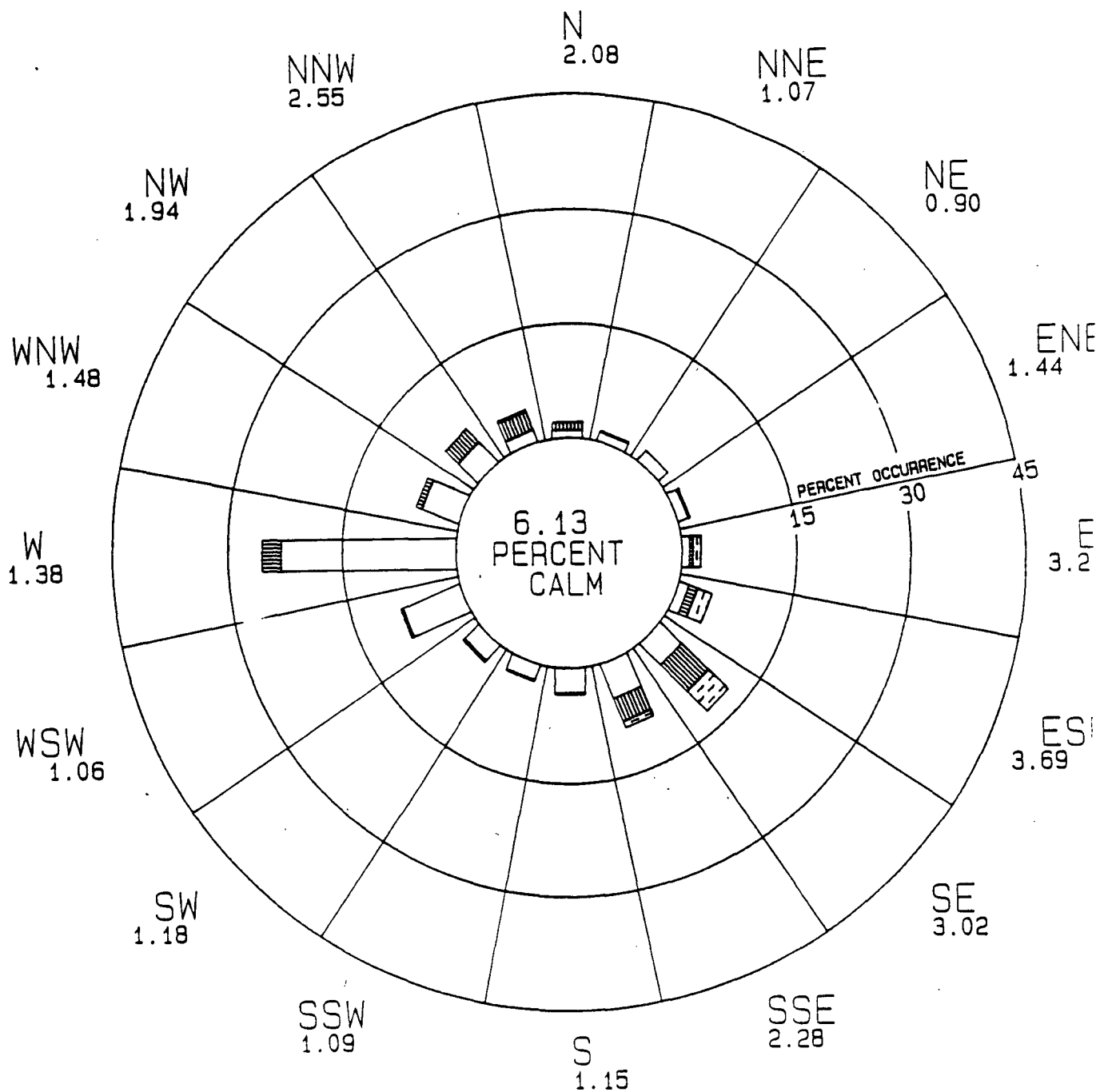
STANDARD OIL
OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
WIND FREQUENCY DISTRIBUTION ANALYSIS

DATA PERIOD - FEB 5, 1977 THROUGH AUG 29, 1980
MONTHS CONSIDERED - JAN THROUGH DEC
HOURS CONSIDERED - 0 TO 2400
ANEMOMETER HEIGHT - 10 METERS

WIND FREQUENCY DISTRIBUTION
FREQUENCY IN PERCENT
OF TOTAL OBSERVATIONS

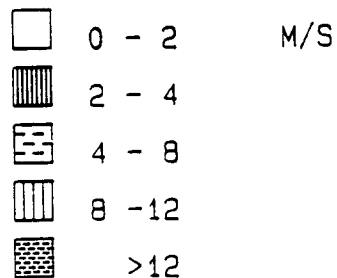
WIND SECTOR	WIND SPEED CLASS (MPS)					TOTAL	MEAN SPEED
	.46 TO 2.00	2.01 TO 4.00	4.01 TO 8.00	8.01 TO 12.00	GREATER THAN 12.00		
NNE	1.22	.15	.00	.00	.00	1.37	1.28
NE	1.24	.07	.00	.00	.00	1.31	1.28
ENE	.97	.31	.20	.02	.00	1.50	2.13
E	.71	.58	1.08	.05	.00	2.41	3.67
ESE	1.02	2.51	2.19	.00	.00	5.72	3.63
SE	3.36	4.49	1.41	.00	.00	9.26	2.65
SSE	4.15	1.78	.17	.00	.00	6.10	1.81
S	5.57	.36	.00	.00	.00	5.92	1.16
SSW	3.44	.42	.00	.00	.00	3.87	1.11
SW	4.22	1.37	.08	.00	.00	5.68	1.49
WSW	8.23	1.50	.05	.00	.00	9.78	1.34
W	11.56	2.80	.15	.00	.00	14.50	1.56
WNW	4.91	2.61	.27	.00	.00	7.79	1.88
NW	3.16	2.53	.36	.00	.00	6.05	2.15
NNW	1.94	2.38	.53	.00	.00	4.84	2.45
N	2.28	1.50	.10	.01	.00	3.88	1.92
CALM						10.02	
TOTAL	57.98	25.34	6.56	.09	.00	100.00	1.74

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 2498
NUMBER OF VALID OBSERVATIONS = 21670



NUMBERS INDICATE SECTOR MEAN WIND SPEED

WIND SPEED RANGE



11831-034

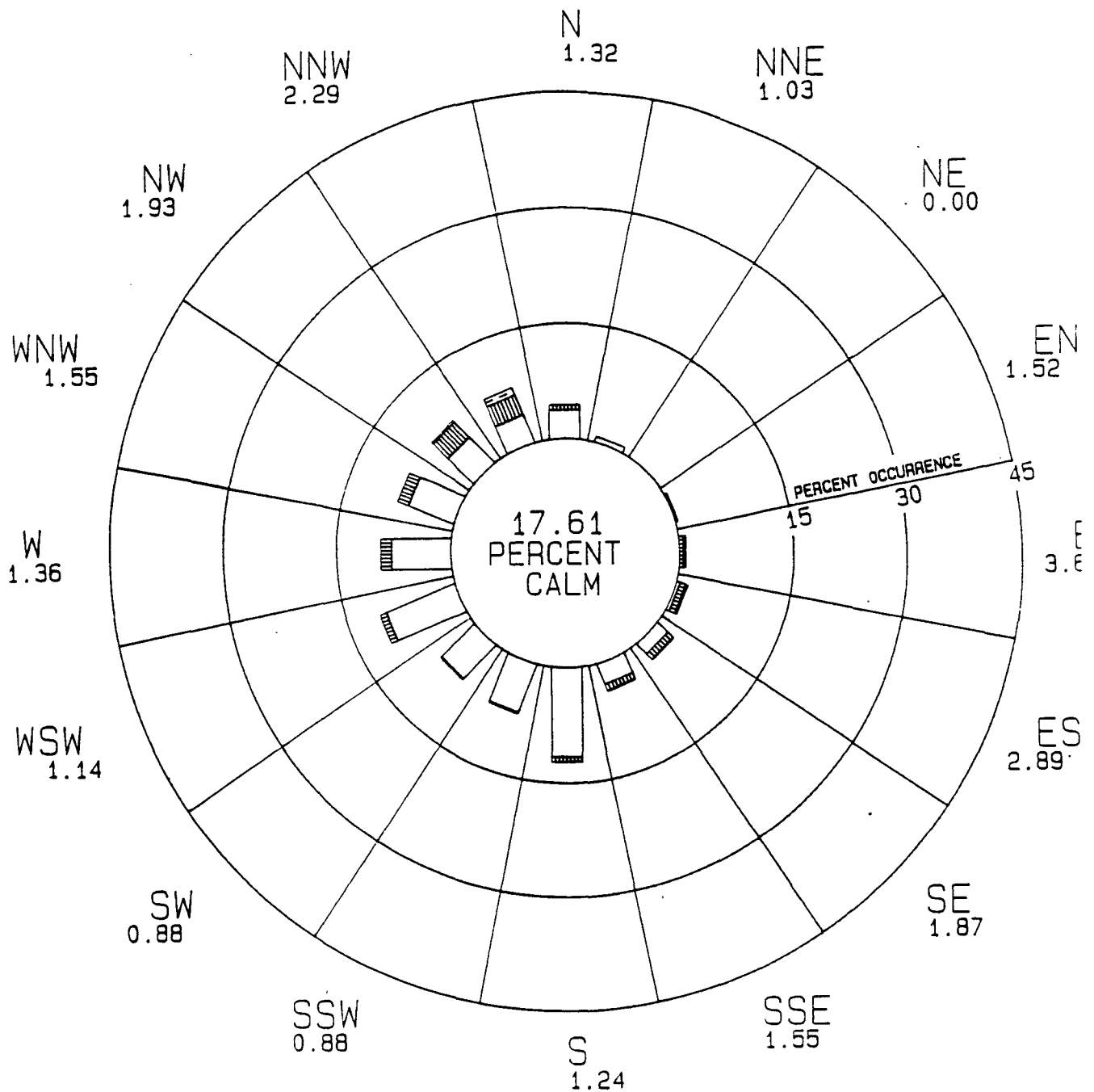
SOURCE:
OREGON DEPT. OF ENVIRONMENTAL QUALITY

NL IND, INC./GOULD, INC.
REMEDIAL INVESTIGATION

WIND FREQUENCY DISTRIBUTION
STANDARD OIL SITE
AUG. 6, 1979 TO NOV. 30, 1979

FIG. 5.3-2

DAMES & MOORE



NUMBERS INDICATE SECTOR MEAN WIND SPEED

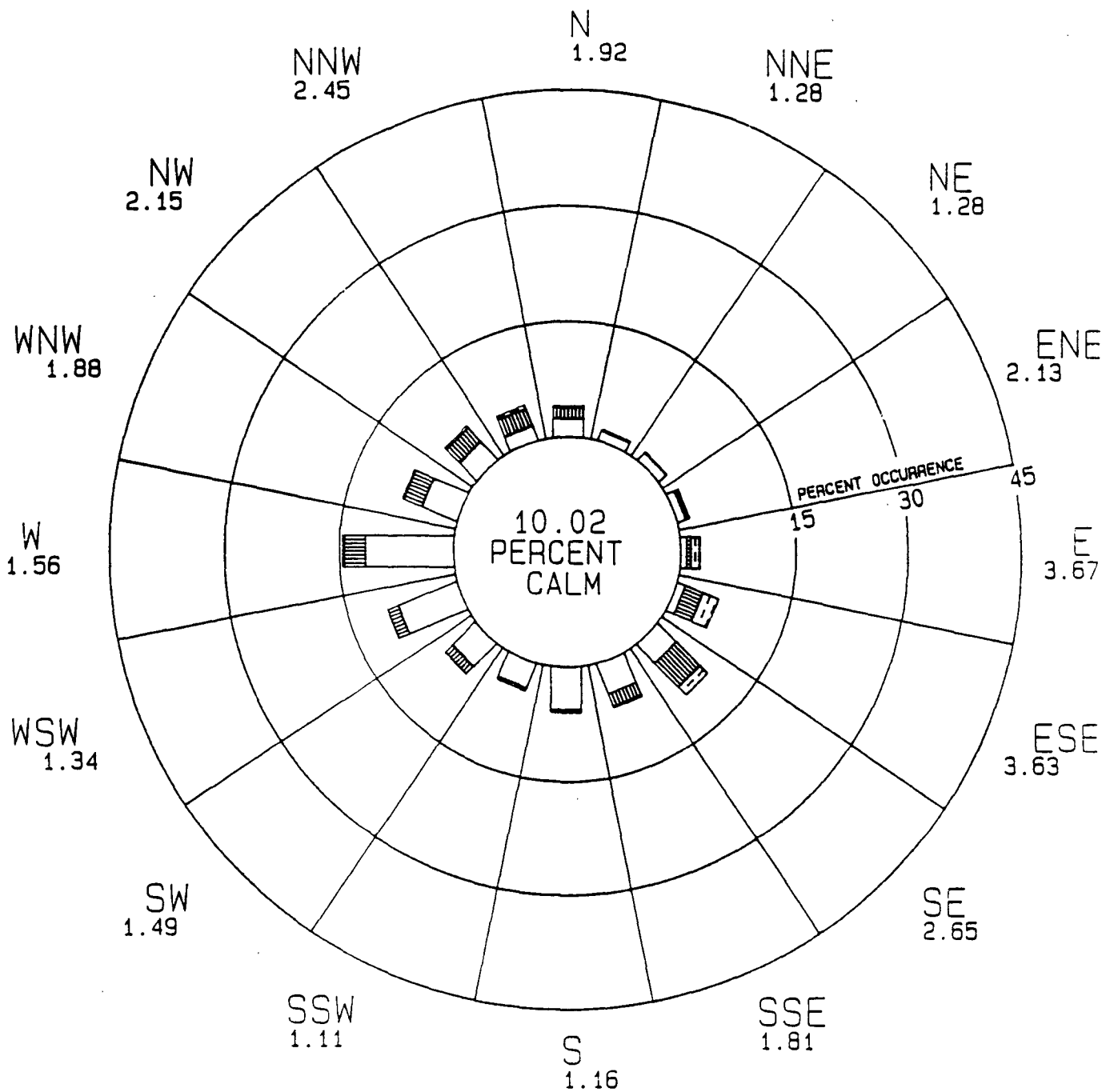
WIND SPEED RANGE

	0 - 2	M/S
	2 - 4	
	4 - 8	
	8 - 12	
	>12	

SOURCE:
OREGON DEPT. OF ENVIRONMENTAL QUALITY

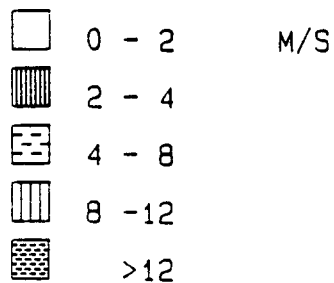
NL IND, INC./GOULD, INC. REMEDIAL INVESTIGATION
WIND FREQUENCY DISTRIBUTION STANDARD OIL SITE AUG. 1, 1977 TO NOV. 30, 1977
FIG. 5.3-3 DAMES & MOO

11831-034



NUMBERS INDICATE SECTOR MEAN WIND SPEED

WIND SPEED RANGE



SOURCE:
OREGON DEPT. OF ENVIRONMENTAL QUALITY

NL IND, INC./GOULD, INC.
REMEDIAL INVESTIGATION

WIND FREQUENCY DISTRIBUTION
STANDARD OIL SITE
FEB. 5, 1977 TO AUG. 29, 1980

FIG. 5.3-4 DAMES & MOORI

11831-034

5.3.3 Quality Control Summary

The purpose of the Quality Assurance/Quality Control (QA/QC) program for the air monitoring program was to ensure that reliable data on airborne contaminants were obtained from the sampling effort for decision making. Details of the QA/QC methods are presented in Appendix B, Section B3.0 and include:

- ° Flow calibrations for the high volume air samplers,
- ° Flow audits,
- ° System precision calculations, and
- ° Analytical audits including analyses of blanks, spikes, matrix spikes, and EPA audit samples.

Results of the QA/QC process indicate that the data obtained for airborne lead and total suspended particulates (TSP) are valid. Statistical analysis of the monitoring network through use of co-located monitors indicate that the quarterly precision statistics for TSP were within the EPA-recommended ± 15 percent on a quarterly basis and improved as the monitoring program progressed. Quarterly precision statistics for airborne lead, while expectedly somewhat higher than for TSP, are still reasonable (there is no EPA-recommended precision level for airborne lead).

During analysis of the QA/QC data, Dames & Moore compensated for an oversight that occurred during the sampling program. The oversight was that an insufficient number of calibrations were performed by the onsite system operator. Dames & Moore's method of compensating for the oversight was to substitute system audits (five-point system audits were performed rather than one-point audits) that were performed by personnel other than the onsite system operator (Dames & Moore technicians) for calibrations of the high volume samplers. This provides assurance that accurate flow measurements were made.

The analytical audit of the data was completed at the end of the air monitoring program, except for matrix spike/matrix spike duplicate testing normally performed by an outside analytical laboratory during

analysis of the sample filters. Re-analysis of 10 percent of the sample filters (selected over the entire range of data and monitoring period) showed sample precision within ± 10 percent, indicating that analytical precision during the project was acceptable. Results of the analysis of blank filters showed lead concentrations below detection limits. Results of analysis of filters spiked with known concentrations of lead showed acceptable recovery statistics.

In addition, samples were obtained and analyzed by the outside analytical laboratory through the EPA National Audit Program, as a check on the analytical precision of the laboratory itself.

5.4 POTENTIAL RISKS

5.4.1 Sources of Airborne Lead On Site

Material containing lead that has the potential to become airborne is found in three different sources in the study area. These are: 1) in the battery casings remaining above-ground on Gould property, 2) in the matte residue disposed of in the landfill on Gould property, and 3) in contaminated soils found on the Gould and Rhone-Poulenc properties. Other lead-containing materials on site (such as subsurface soils and Doane Lake remnant sediments) are not exposed to the atmosphere under present conditions, and therefore cannot become airborne. During remedial activities when contaminated materials are disturbed or excavated, however, the potential for lead contained in the material to become airborne is greatly increased. It is not possible to partition contributions to the total airborne lead by the various sources, given their proximity to each other.

5.4.1.1 Battery Casing Piles

The primary sources of airborne lead on site are the piles of shredded battery casings. These casings contain large amounts of finely divided lead and lead oxide not recovered during battery recycling operations. From analyses performed on the casings, the lead content ranges from about 3.1 percent to 14.5 percent. For details of the casing composition, see Section 3.2.4. The mounds of casings are exposed to

winds, although during the remedial investigations, some of the piles were covered with tarps to reduce the potential for lead to become airborne.

5.4.1.2 Matte Disposal Area

A major waste product of the secondary smelting process is "matte". This slag-like material is very heavy and high in metal content, particularly iron. Lead concentrations observed in the samples taken varied from 6 percent to over 11 percent. For more details on matte composition, see Section 3.2.4. The matte was primarily disposed below-grade on the Gould property, next to and under the battery casings. Therefore the potential for generation of airborne lead particles is significantly less than for battery casings, since very little matte surface area is exposed to airflow relative to the amount of material disposed.

5.4.1.3 Contaminated Soils

As discussed above, only soils exposed to the atmosphere (surface soils) presently contribute to airborne lead concentrations. The amount of surface soils significantly contaminated with lead is very limited on the Gould property since most of the site is presently covered with asphalt, concrete, battery casings, or the East Doane Lake remnant. Surface soil lead concentrations of up to 2 percent were observed on the Gould property during sampling by Dames & Moore. Additional contaminated surface soils were observed, however, on the Rhone-Poulenc property west of the Gould property. For more details on surface soil lead concentrations and distribution of contaminated soils, see Section 4.2.4.3.

5.5 POTENTIAL ATMOSPHERIC CONTAMINANT MIGRATION

The shutdown of the secondary lead smelter in 1972 ended the sources of lead emissions resulting from thermal processes (i.e., lead fume resulting from the handling of molten lead). Airborne lead from sources on site now results from atmospheric dust arising from the mechanical disturbance of remaining lead-contaminated site materials exposed to the

air. Dust generated from these open sources is termed "fugitive" because it is not discharged to the atmosphere in a confined airflow stream such as a stack. Common sources of fugitive dust include unpaved roads, agricultural tilling, granular materials storage and handling, and heavy construction activities. For this site, the primary activities leading to emissions of lead-containing dust are materials storage and handling (or casings and matte piles and related cleanup activities) and travel over unpaved surfaces on site.

The fugitive dust generation process is caused by three basic physical actions:

1. Pulverization and abrasion of surface materials by application of mechanical force such as tires or digging implements;
2. Entrainment of dust particles by the turbulent action of air currents from either the wind moving across exposed surfaces, or air displacement during materials transfer; and
3. Erosion of exposed surfaces by high wind velocities (exceeding about 12 miles per hour).

At present, airborne lead results primarily from entrainment caused by wind action on exposed surfaces, primarily the battery casing piles, contaminated surface soils and the exposed matte. Several factors affect the potential for dust generation from surfaces by entrainment. First, the amount of finely-divided particles containing lead is directly proportional to the emission potential. Battery casings, for instance, contain significant quantities of finely-divided lead and lead oxide particles. Small particles become easily suspended with lower levels of turbulent airflow; they also remain suspended in the air longer because their settling velocities are low as well. Small particles of less than 10 micrometers represent a higher potential human health risk since they can pass through the filtering mechanisms of the upper respiratory tract and penetrate the lungs.

The moisture content of the material affects dust generation potential because water tends to agglomerate and cement the fine particles

together (and to the surfaces of large particles) so that they act like much larger particles. Larger particles are much less likely to become airborne, and they settle quickly because of their mass. Surface tension effects of water that accompanies higher moisture contents also reduces of air entrainment of particles. During the wet season months, the high moisture content of the soils and the wet surface of the mat on site helps reduce airborne lead emissions. Unfortunately, the beneficial effects of moisture last only as long as the moisture is present. Dry season months, correspondingly, will have higher levels of fugitive dust and airborne lead.

Exposure to the wind and the effects of sheltering can affect the rate of entrainment and erosion of particulate matter. Sheltering has the effect of reducing wind speed over the exposed surface and thus minimizes the turbulent action of the air. The tarps applied to the battery casing piles were effectively a sheltering control measure. However, the tarps were inadequately secured at the time of installation and, during high wind conditions, became dislodged on several occasions. This negates the sheltering effect and enhances the particulate entrainment at precisely the time when entrainment and erosion potential is highest due to air turbulence from high wind speeds.

Entrainment due to air displacement during handling (loading, dumping, etc.) of contaminated materials has not been a factor during the remedial investigation because contaminated materials have not been appreciably disturbed. However, this factor will become important when future remedial actions occur and the contaminated material piles must be disturbed. Since the piles have been in place for number of years, emissions of lead-contaminated dust from them will have been minimized to some extent. Freshly-placed piles have higher emissions until fine particles at the surface have been emitted, have settled or have agglomerated leaving larger, less mobile particles at the surface. Disturbing aged piles, however, will increase the potential for emissions because of the freshly exposed surfaces and the localized air turbulence from the loading and dumping operations.

Control measures can be taken to reduce the potential for airborne lead emissions during materials handling. Measures that have been

demonstrated to be effective include the application of dust suppressants, water sprays and use of portable windscreens. Additionally, displaced air turbulence can be slightly minimized by reducing drop distances during unloading into haul equipment or hoppers.

Pulverization and abrasion resulting from the application of mechanical force at the site has been limited during the remedial investigation to principally traffic on unpaved surfaces during the dry season months and to the cleaning and decontaminating of the battery casing separation equipment during August and September 1986. The observed airborne lead levels, however, indicate that if prolonged activities of this nature were to occur, airborne lead levels could reach unacceptable levels unless control actions were taken. Emissions control actions include application of dust suppressants to unpaved areas where vehicles frequently travel.

6.0 BIOTA INVESTIGATION

6.1 FLORA

6.1.1 Site and Local Distribution

The Gould site is largely devoid of vegetation. Much of the site surface area is paved or covered with battery casings. A few ornamental evergreen trees exist around the office building. Other vegetation in the site area is largely confined to the perimeter of the East and West Doane Lake remnants, and consists of annual and perennial grasses, blackberries, and small woody shrubs. No rare, threatened, or endangered plant species are known to occur on the site.

6.1.2 Contaminant Concentrations

No data were located for contaminant uptake and incorporation by onsite vegetation. Studies to determine this were not considered for the scope of this Remedial Investigation.

6.2 FAUNA

6.2.1 Site and Local Distribution

Onsite occurrence of animals is low due to limited habitat. Several species of birds are the most common animals frequenting the site, including sparrows, thrushes, swallows, and other passerines, as well as mallards that regularly frequent the East Doane Lake remnant. Onsite mammals are probably limited to ground squirrels and rats.

Aquatic organisms in the Doane Lake remnants include aquatic invertebrates and frogs. No fish have been observed in either of the lake remnants.

No rare, threatened, or endangered animal species are known to occur on the site.

6.2.2 Contaminant Concentration

No data were located for contaminant concentrations in onsite fauna. Studies to investigate this were not considered for the scope of this remedial investigation. The Oregon Department of Environmental Quality (DEQ) conducted sampling for toxicants in sediment, water, and fish and invertebrate tissue in the Willamette River adjacent to the site (River Miles 6.8 to 7.1) from 1980 through 1982. Tissue metals concentrations were analyzed for both invertebrates (crayfish) and fish (various species) (Oregon DEQ 1982). Both fish and crayfish tissue samples were composited for analyses. Crayfish collected at the river station near Doane Lake were found to have a tissue lead concentration of 0.68 parts per million (ppm). Fish from the river station at the SP&S Railroad Bridge were tested for tissue metals concentration. Peamouth collected on January 27, 1981 were found to have a tissue lead level of 0.29 ppm. Three species collected on October 6, 1981 (peamouth, sucker, and chiselmouth) were below the detection limit for lead [0.1 ppm]).

7.0 BENCH SCALE STUDIES

7.1 INTRODUCTION

The following sections describe the bench scale studies undertaken during the Gould Remedial Investigation. The purpose and scope, procedures, results, and conclusions of the following three tests are presented: (1) battery casing coating test; (2) batch adsorption test; and (3) leach potential test.

7.2 BATTERY CASING COATING TEST

7.2.1 Purpose

The purpose of the battery casing coating test was to assess the potential for three different coating formulations to minimize the leaching of lead from the casing material. The test material consisted of a composite of 12 battery casing samples collected as part of the battery casing sampling program (Section 3.2.3). Three coating materials were evaluated: (1) a proprietary lead control compound (K-20 Lead-In-Soil Control Mixture); (2) a non-proprietary chemical coating compound (sodium silicate); and, (3) an epoxy paint. Aliquots of the composite battery casing sample were coated with one of the coating materials and each coated sample was extracted and analyzed for lead according to EP Toxicity test procedures.

7.2.2 Procedure

The composite battery casing sample was prepared by combining representative 80-gram portions of 12 individual battery casing samples. The twelve representative portions were taken from samples that had already been prepared for analysis by EP Toxicity procedures (i.e., particle size reduced to pass the appropriate screen size) during the battery casing sampling program. The composited sample was divided into four equal samples and the individual samples were screened again with a No. 14 sieve mesh screen to remove particles that would be lost during the coating procedure. Forty grams of each sample retained on the screen were used in the coating test. The four screened samples were

labeled A, B, C, and D. The D sample was held for future analysis; the A, B, and C samples were treated as follows:

- A. The proprietary coating solution K-20 ICS/LS was delivered to the analytical laboratory in two parts, part A and B. The solutions were mixed at a 10:1 ratio by mixing 250 milliliters (mls) of part A with 25 ml of part B. The 40-gram battery casing sample labeled A was added to the mixed coating solution, stirred for one minute and then strained. The coated material was spread out on mixing paper and dried for 26 hours. The dried, coated material was extracted and analyzed as described below.
- B. The sodium silicate solution was obtained by the analytical laboratory and was identified as Banco (TM), Anderson Laboratories, Inc. No. 68330, 4 liters sodium silicate 41° Be solution (water glass-technical). The 40-gram battery casing sample labeled B was added to a beaker containing 200 ml of the sodium silicate solution and stirred for one minute. The coated material was spread out on mixing paper and dried for 26 hours. The dried, coated material was extracted and analyzed as described below.
- C. The epoxy spray paint was delivered to the analytical laboratory and was identified as Zynolyte epoxy spray paint, clear 0537 (net wt. 13 oz.). The 40-gram battery casing sample labeled C was placed in a plastic bag filled with air and epoxy spray mist. The bag was sealed and shaken to lightly coat all surfaces of the material. The casing material was then spread onto mixing paper and sprayed with additional paint. A total of approximately 4 oz. of spray paint mixture was used. The coated material was dried for 26 hours and the dried, coated material was extracted and analyzed as described below.

The three coated battery casing samples were extracted by EP Toxicity procedure EPA method 1310, without the grinding and/or screening steps. The 40-gram samples were extracted with 640 mls of deionized

water. The pH was adjusted with the required volume of acetic acid during the extraction to adjust the pH of the samples to 5 ± 0.2 . The extracts were analyzed for lead by EPA method 6010 (ICP).

7.2.3 Results

The results of the battery casing coating test are presented in Table 7.2-1. The laboratory data report has been submitted previously (Dames & Moore, 1987).

TABLE 7.2-1

BATTERY CASING COATING TEST RESULTS

Sample Designation	Extract Lead Concentration (mg/l)
A	290
B	520
C	30

The results of the battery casing coating test indicate that none of the three coating formulations tested reduced the leachable lead concentration below the accepted standard concentration established to identify a waste as hazardous or non-hazardous. (Maximum contamination level [MCL] for lead in the EP Toxicity test is 5 mg/l.) The epoxy spray had the best overall reduction in leachable lead with an extract lead concentration of 30 mg/l. However, this concentration is still six times higher than the MCL.

7.2.4 Conclusions

The following conclusions are based on the results of the battery casing coating test:

1. The coating formulations tested were not effective in reducing the leachable lead concentration below acceptable levels; and

2. The epoxy resin coating resulted in the largest reduction in leachable lead concentration. Larger quantities and/or additional coatings of epoxy paint may further reduce the leachable lead concentration. However, the logistical difficulties of application to large volumes of battery casing materials, the large quantities of coating spray necessary, and the potential toxic or hazardous nature of the coated material makes this an impractical treatment alternative.

7.3 BATCH ADSORPTION TEST

7.3.1 Purpose and Scope

The purpose of the batch adsorption test was to evaluate the soil/water interactions between representative site soil samples and dissolved lead in representative site ground water. These soil/water interactions include adsorption and desorption interactions between dissolved lead in ground water and soil particles. Adsorption results in removal of dissolved lead from the ground water by the soil material, thereby reducing the ground-water lead concentration and mobility. Desorption results in a release of lead associated with the soil material into the ground water, thereby increasing the ground-water lead concentration. Emphasis was placed on the effect of these interactions with respect to the dissolved lead retardation potential by the soils (adsorption). The procedure has been extensively used by soil scientists and geochemists concerned with determining retardation parameters suitable for modeling contaminant transport (Relyea, et al. 1980; Pavlik and Runnells 1984).

The batch adsorption test consisted of equilibrating representative samples of different site soil types with representative site water containing different concentrations of dissolved lead. Twelve soil samples including six surface soil, four subsurface soil and two sediment samples, were collected for this test during their respective sampling programs. The collection procedures are described in Appendix A. Representative site ground water was collected immediately before the test was initiated. The site water was spiked with four

different dissolved lead concentrations ranging from 0.0 to 2.0 mg/l. The samples were equilibrated for 24 hours, the filtered and analyzed for dissolved lead and other water quality parameters.

The results of the batch adsorption test are used to determine the R_d parameter, a measure of the partitioning of lead between soil and water. The R_d parameter for lead is defined and calculated as follows:

$$R_d = \frac{(\text{mass of Pb adsorbed per gram of soil})}{(\text{mass of Pb in solution after equilibration period})}$$

The R_d parameter is determined by plotting an adsorption isotherm for the data collected in the batch test. This defines the partitioning relationship for Pb between the solid phase and the ground-water solution. For each sample type, the following calculation is made:

$$S = (C_o - C) V/M$$

where

S = amount of lead adsorbed on soil
C_o = initial concentration of Pb in solution
C = final concentration of Pb in solution after the
equilibration period
V = total volume of fluid
M = total mass of soil

A plot of S versus C determines the partitioning function for each sample type. The slope of this partitioning function is the lead R_d for each sample type.

The value of the R_d parameter rests in its ability to describe the partitioning of a dissolved contaminant between the soil and the ground water in contact with the soil. Generally, the partitioning relationship observed in the adsorption isotherm is linear in the range of concentrations observed under field conditions. Therefore, the R_d can be directly used in the advection-dispersion equation in the development of models for predicting the rate of contaminant movement in ground water.

In predictive models, R_d is used to calculate a retardation factor defined in the retardation equation as follows:

$$R = 1 + (p R_d/n)$$

where

- p = bulk density of porous medium
- n = porosity of porous medium
- R_d = retardation coefficient or distribution coefficient
- R = retardation factor

The retardation factor is used to calculate the velocity of the dissolved contaminant movement relative to the velocity of ground water.

7.3.2 Procedure

The batch adsorption test was conducted following the procedures described below:

1. Twelve representative soil samples were screened so that only materials passing a 2-millimeter (mm) screen were used. Each of the 12 samples were split into five subsamples weighing 80 grams each. The five subsamples were placed into clean, acid-washed bottles and labeled 1 through 5.
2. Five solutions were made with representative ground water. One solution was not spiked and therefore had a dissolved lead concentration representative of the collected site water. The remaining four solutions were spiked so that resulting dissolved lead concentrations were 0.5, 1.0, 1.5 and 2.0 mg/l. The representative site water (no spike) was placed in bottle 1 and the four spike solutions were placed in bottles 2 through 5. The volume of solution placed in each bottle was 400 ml.
3. One set of five bottles containing the same 400-ml solutions used in step (2) but with no soil were also prepared. These bottles were prepared as the blank or control samples to monitor the changes in concentrations not due to soil/water interactions.
4. The 60 bottles containing soil and water and the five bottles with only water were equilibrated for 24 hours at constant temperature.

5. After the 24-hour equilibration period, the bottles were centrifuged and the decanted solution from each bottle was filtered through a 0.45 micron filter. The filtrate was split into two portions, A and B.
6. Filtrate portion A was analyzed for pH, specific conductance, alkalinity, sulfate, and chloride.
7. Filtrate portion B was acidified with nitric acid to pH <2 and the acidified sample was analyzed for the dissolved constituents lead, arsenic, sodium, potassium, calcium, magnesium, iron, and zinc.

7.3.3 Results

The results of the batch adsorption test are presented below (Table 7.3-1). The four samples, one subsurface sample (W-7S-20'), one sediment sample (SD-3) and two surface soil samples (S-9 and S-13), all had total lead concentrations in the soil greater than 800 mg/kg. The results indicate that four of the samples had lead concentrations remaining in the equilibrated solutions above the detection limit (0.01 mg/l). The average lead concentration remaining in the equilibrated solutions in these four samples were 0.052 mg/l in sample W-7S-20', 0.004 mg/l in sample SD-3, 0.27 mg/l in sample S-9 and 0.072 mg/l in sample S-13.

The results indicate that resulting solution lead concentrations were relatively constant for a given sample, further indicating that there was no effect of initial solution lead concentration on the adsorption/desorption mechanisms. An example of this can be seen in the results for the S-9 sample. The spike lead concentration ranged from 0.0 to 2.0 mg/l but the equilibrated lead concentrations in the 5 solutions show no direct relationship to these increasing concentrations of lead in the initial spike solutions. In addition, the results for samples W-7S-20', S-9 and S-13 indicate that the samples leached lead into the 0.0 and 0.5 mg/l initial spike solutions (as indicated by a negative amount adsorbed in Table 7.3-2).

TABLE 7.3-1
BATCH ADSORPTION TEST RESULTS

SAMPLE NUMBER	Soil Pb Concen- tration (mg/kg)	Pb Spike Concen- tration (mg/l)	pH	Pb (mg/l)	As (mg/l)	Zn (mg/l)	Fe (mg/l)	Na (mg/l)	K (mg/l)	Ca (mg/l)	Hg (mg/l)	Cl (mg/l)	SO ₄ (mg/l)	Alkalinity (as CaCO ₃) (mg/l)	EC (umhos/cm)
BLANK	---	0.0	6.1	U0.01	U0.005	0.006	0.01	1.6	0.2	4	0.2	U1	2	6	26
		0.5	5.9	0.04	U0.005	0.110	0.01	2.4	0.3	U0.01	0.1	U1	1	6	16
		1.0	4.2	0.43	U0.005	0.140	U0.01	2.3	0.4	U0.01	0.1	U1	1	U1	37
		1.5	3.8	0.92	U0.005	0.160	0.09	2.4	0.4	U0.01	0.1	U1	U1	U1	72
		2.0	3.5	1.40	U0.005	0.170	U0.01	2.5	0.4	U0.01	U0.01	U1	U1	U1	110
		Average	4.7	0.56	0	0.117	0.02	2.2	0.3	0.8	0.1	0	0.8	2.4	52.2
W-6S-26'	16	0.0	7.0	U0.01	U0.005	0.084	0.03	39	8.4	98	47	20	10	490	1000
		0.5	7.2	U0.01	U0.005	0.072	U0.01	39	8.4	88	45	18	10	480	990
		1.0	7.1	U0.01	U0.005	0.069	U0.01	40	8.4	96	47	18	10	440	980
		1.5	7.2	U0.01	U0.005	0.077	U0.01	39	8.4	93	46	18	10	450	990
		2.0	7.0	U0.01	U0.005	0.069	U0.01	40	8.4	94	46	19	9	450	990
		Average	7.1	0.00	0	0.074	0.01	39	8.4	92	46	18.6	10	462	990
W-7S-20'	820	0.0	6.2	0.06	U0.005	0.580	0.05	63	7.2	69	28	16	180	250	960
		0.5	6.2	0.05	U0.005	0.550	0.17	64	7.2	68	28	17	180	240	970
		1.0	6.2	0.05	U0.005	0.550	0.06	64	7.2	68	27	16	180	230	880
		1.5	6.2	0.05	U0.005	0.560	0.08	66	7.2	58	28	16	170	230	880
		2.0	6.3	0.05	U0.005	0.550	0.15	67	7.2	62	28	16	180	230	870
		Average	6.2	0.05	0	0.558	0.10	65	7.2	65	28	16.2	178	236	872
B-6-21'	74	0.0	6.9	U0.01	U0.005	0.086	0.24	62	9.6	90	51	16	120	480	1200
		0.5	7.0	U0.01	U0.005	0.083	0.13	68	9.4	92	49	16	110	480	1200
		1.0	7.0	U0.01	U0.005	0.075	0.26	68	9.6	91	50	17	120	470	1200
		1.5	7.1	U0.01	U0.005	0.071	0.21	70	9.6	90	50	16	120	470	1200
		2.0	7.1	U0.01	U0.005	0.079	0.29	70	9.6	89	48	16	120	450	1200
		Average	7.0	0.00	0	0.079	0.23	68	9.6	90	50	16.2	118	470	1200
B-8-32'	41	0.0	6.7	U0.01	U0.005	0.140	0.23	69	8.0	54	31	53	56	340	940
		0.5	6.7	U0.01	U0.005	0.140	0.03	69	8.0	54	30	57	60	320	920
		1.0	6.6	U0.01	U0.005	0.140	0.06	69	8.0	55	30	62	52	320	940
		1.5	6.7	U0.01	U0.005	0.140	0.25	69	8.0	55	31	48	48	320	940
		2.0	6.7	U0.01	U0.005	0.140	0.12	70	8.0	56	31	48	49	320	940
		Average	6.7	0.00	0	0.140	0.14	69	8.0	55	31	53.6	53	324	936
S-1	500	0.0	6.5	U0.01	U0.005	0.200	0.56	29	7.8	54	23	12	10	310	660
		0.5	6.4	U0.01	U0.005	0.190	0.15	28	7.6	53	22	11	9	310	630
		1.0	6.5	U0.01	U0.005	0.200	0.11	29	7.6	53	22	9	7	290	630
		1.5	6.5	U0.01	U0.005	0.180	0.21	29	7.6	56	23	12	10	290	630
		2.0	6.5	U0.01	U0.005	0.200	0.18	29	7.6	56	23	11	10	290	640
		Average	6.5	0.00	0	0.194	0.24	29	7.6	54	23	11	9	298	638

TABLE 7.3-1
BATCH ADSORPTION TEST RESULTS

SAMPLE NUMBER	Soil Pb Concen- tration (mg/kg)	Pb Spike Concen- tration (mg/l)	pH	Pb (mg/l)	As (mg/l)	Zn (mg/l)	Fe (mg/l)	Na (mg/l)	K (mg/l)	Ca (mg/l)	Hg (mg/l)	Cl (mg/l)	SO ₄ (mg/l)	Alkalinity (as CaCO ₃) (mg/l)	EC (umhos/cm)
S-9	20000	0.0	6.3	0.26	0.017	0.610	0.07	30	15	190	30	18	400	150	1300
		0.5	6.4	0.28	0.013	0.670	0.29	29	15	180	30	18	430	140	1300
		1.0	6.3	0.28	0.012	0.630	0.12	30	15	190	30	19	390	140	1300
		1.5	6.4	0.24	0.012	0.590	0.12	30	15	190	30	19	420	140	1400
		2.0	6.3	0.29	0.011	0.720	0.15	30	15	200	29	18	400	140	1300
		Average	6.3	0.27	0.013	0.644	0.15	30	15	190	30	18.4	408	142	1320
S-13	1400	0.0	6.7	0.06	0.005	0.140	0.12	28	9.8	69	26	11	31	330	710
		0.5	6.6	0.07	0.005	0.150	0.14	28	9.8	72	27	11	27	330	710
		1.0	6.7	0.06	0.005	0.160	0.11	28	9.8	71	28	11	25	330	710
		1.5	6.6	0.08	0.005	0.130	0.09	27	10	71	28	10	24	330	720
		2.0	6.7	0.09	0.005	0.140	0.11	28	10	73	28	11	28	330	730
		Average	6.7	0.07	0	0.144	0.11	28	9.9	71	27	10.3	27	330	716
S-37	16	0.0	7.4	0.01	0.005	0.088	0.02	31	3.2	82	60	12	9	510	920
		0.5	7.4	0.01	0.005	0.073	0.08	31	3.0	76	56	11	9	500	920
		1.0	7.4	0.01	0.005	0.089	0.08	31	3.0	76	54	11	9	500	910
		1.5	7.4	0.01	0.005	0.081	0.15	30	3.0	81	54	11	9	480	920
		2.0	7.4	0.01	0.005	0.088	0.05	29	3.2	77	54	11	9	480	920
		Average	7.4	0.00	0	0.085	0.08	30	3.1	78	56	11.2	9	494	918
S-45	20	0.0	7.5	0.01	0.005	0.089	0.02	29	3.8	77	66	16	9	510	980
		0.5	7.6	0.01	0.005	0.100	0.02	30	3.8	78	64	12	9	510	970
		1.0	7.5	0.01	0.005	0.081	0.07	29	3.6	77	64	12	8	500	990
		1.5	7.5	0.01	0.005	0.070	0.01	29	3.6	76	66	12	10	500	990
		2.0	7.5	0.01	0.005	0.074	0.01	30	3.6	74	64	12	9	500	990
		Average	7.5	0.00	0	0.083	0.03	29	3.7	76	65	12.8	9	504	984
S-57	45	0.0	6.5	0.01	0.005	0.130	0.09	28	5.6	46	19	12	9	250	540
		0.5	6.4	0.01	0.005	0.140	0.11	28	5.6	46	18	12	9	250	540
		1.0	6.4	0.01	0.005	0.130	0.11	28	5.6	45	19	12	9	250	550
		1.5	6.4	0.01	0.005	0.140	0.15	28	5.8	44	19	14	10	250	550
		2.0	6.4	0.01	0.005	0.140	0.16	28	5.6	46	18	12	9	240	550
		Average	6.4	0.00	0	0.136	0.12	28	5.6	45	19	12.4	9	248	546

TABLE 7.3-1
BATCH ADSORPTION TEST RESULTS

SAMPLE NUMBER	Soil Pb Concen- tration (mg/kg)	Pb Spike Concen- tration (mg/l)	pH	Pb (mg/l)	As (mg/l)	Zn (mg/l)	Fe (mg/l)	Na (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	SO ₄ (mg/l)	Alkalinity (as CaCO ₃) (mg/l)	EC (umhos/cm)
SD-7	26	0.0	7.0	0.01	0.005	0.110	0.04	41	6.8	72	38	13	39	410	840
		0.5	7.0	0.01	0.005	0.100	0.03	40	6.8	73	40	13	39	410	840
		1.0	7.0	0.01	0.005	0.110	0.06	41	6.8	71	39	12	40	410	850
		1.5	6.9	0.01	0.005	0.100	0.04	41	6.8	73	39	13	43	400	860
		2.0	6.9	0.01	0.005	0.110	0.03	41	6.8	74	40	13	40	400	860
		Average	7.0	0.00	0	0.106	0.04	41	6.8	73	39	12.8	40	406	850
SD-3	160	0.0	7.4	0.01	0.005	0.084	0.10	36	7.4	120	28	14	34	490	1000
		0.5	7.5	0.02	0.005	0.200	0.01	37	7.4	110	27	16	36	500	1100
		1.0	7.3	0.01	0.005	0.085	0.01	36	7.4	110	27	15	37	490	1000
		1.5	7.3	0.01	0.005	0.140	0.07	36	7.4	110	27	16	35	490	1000
		2.0	7.3	0.01	0.005	0.087	0.02	36	7.4	110	28	15	36	480	1100
		Average	7.4	0.00	0	0.119	0.04	36	7.4	112	27	15.2	36	490	1040

TABLE 7.3-2

CALCULATION SUMMARY TABLE

	Initial Lead Spike Concentration (mg/l)	Corrected Lead Spike Concentration ¹ (Co) (mg/l)	Equilibrium Solution Lead Concentration (mg/l)	Amount of Lead Adsorbed on Soil (S) (mg/g)
W-6S-26'2	0.0	U0.01	U0.01	0.00
	0.5	0.04	U0.01	0.20
	1.0	0.43	U0.01	2.15
	1.5	0.92	U0.01	4.60
	2.0	1.40	U0.01	7.00
W-7S-20'	0.0	U0.01	0.06	-0.30
	0.5	0.04	0.05	-0.05
	1.0	0.43	0.05	1.90
	1.5	0.92	0.05	4.35
	2.0	1.40	0.05	6.75
S-9	0.0	U0.01	0.26	-1.30
	0.5	0.04	0.28	-1.20
	1.0	0.43	0.28	0.75
	1.5	0.92	0.24	3.40
	2.0	1.40	0.29	5.55
S-13	0.0	U0.01	0.06	-0.30
	0.5	0.04	0.07	-0.15
	1.0	0.43	0.06	1.85
	1.5	0.92	0.08	4.20
	2.0	1.40	0.09	6.55
SD-3	0.0	U0.01	U0.01	0.00
	0.5	0.04	0.02	0.10
	1.0	0.43	U0.01	2.15
	1.5	0.92	U0.01	4.60
	2.0	1.40	U0.01	7.00

(1) Corrected for adsorptive loss of 0.5 mg/l in blank.

(2) Representative of all samples with equilibrium solution lead concentrations below detection limit.

The results suggest that the controlling factor that determines the equilibrium solution lead concentration is the soil lead concentration and not the initial solution concentration. The results also indicate that the lead adsorption/desorption is probably due to surface adsorption and/or ion exchange mechanisms. The apparent anomalously low equilibrium solution lead concentration in sample SD-3 is probably due to the higher pH of the sediment (9.7) which may have influenced the adsorption/desorption mechanisms, possibly enhancing the pH controlled precipitation mechanism, thus lowering lead solubility in the solution.

The blank solution (no soil) results indicate that, in general, the concentrations of the parameters in the blank solutions remained constant throughout the test. The pH of the solutions dropped with increasing spike lead concentrations. This is probably due to the low pH of the spike solutions. There also appears to be an adsorptive loss of spike lead to the walls of the equilibration containers. This loss, approximately 0.5 mg/l, was constant throughout the range of spike solution concentrations and had little or no influence on the test results.

Comparison of the blank results to the sample results indicates that the sample soils leached most of the parameters other than lead into solution. Sample S-9 is the only sample indicating leaching of arsenic. All the samples leached the common element parameters (i.e., calcium, sodium etc.) into solution, as would be expected.

The R_d parameter was not calculated since lead was essentially removed from the solutions quantitatively. As described above (Section 7.3.1), the plotted slope of the lead amount adsorbed from solution per gram of sample (S) versus the equilibrium lead solution concentration (C) would yield the R_d parameter. These values are presented below (Table 7.3-2). Since the equilibrium lead solution concentrations (C) are nearly constant for all samples, the slope of the line is vertical and the R_d parameter approaches infinity for all the samples. This result indicates that, under conditions simulated by this test, soils and sediments at the site have a high potential for lead adsorption.

7.3.4 Conclusions

The following conclusions are based on the results of the batch adsorption test:

1. Within the range of solution lead concentrations and compositions studied, the controlling factor in equilibrium solution lead concentration appears to be the total lead concentration in the soil and not the initial solution lead concentration.
2. The adsorptive capacity of the soils and sediments studied is 100 percent for lead when the total soil lead concentration is less than 800 mg/kg. Samples with higher total soil lead concentrations also have adsorptive capacities. Therefore, the results indicate that under the same conditions of this test, site soils and sediments probably have adsorptive capacities that lead to inhibited lead migration.

7.4 LEACH POTENTIAL TEST

7.4.1 Purpose and Scope

The purpose of the leach potential test was to evaluate the potential for lead to leach from primary source material (battery casing and matte) and secondary source material (contaminated soils and sediment) into the ground water under varying conditions of pH. The effect of organics present in the ground water on the potential for lead leaching was also evaluated.

The five sample types used in the leach potential test consisted of battery casing, matte, surface soil, subsurface soil, and sediment samples. One sample of each representative type of lead-containing material (lead concentration >100 mg/kg) was used in the test. When there was not enough of a particular sample, a composite sample was used. The leach solutions consisted of pH-adjusted tap water that encompassed the 2.8 - 12.5 pH range of the ground water measured at the site. The hardness and sulfate concentrations of the tap water were

adjusted with magnesium and calcium sulfate salts to levels representative of the site water. Ground water obtained from the site with potentially high concentrations of organics was used as well. The leach solutions were analyzed for pH, dissolved lead, and arsenic after an equilibration period of 24 hours.

7.4.2 Procedure

The leach potential test was conducted following the procedures described below:

1. The five sample types used in the leach test were analyzed for pH, percent solids, total lead and total arsenic before the test began.
2. Each sample type was divided into four portions, each weighing 80 grams. For each of the five material types, the four portions were placed into four clean, acid-washed bottles and labeled 1 through 4. A duplicate set of bottles was prepared for one of the sample types and an additional set of bottles was prepared as a blank (no soil added). A total number of 28 bottles were prepared.
3. Four leach solutions were prepared for the leach test. Three of the solutions were prepared with tap water. Calcium and magnesium sulfate salts were added to bring the hardness of the tap water to a level representative of the site water (500 mg/l). The pH of these three solutions was adjusted with sulfuric acid and sodium hydroxide to desired levels of 2.8, 6.0 and 12.0, respectively. Representative site water with high organics concentrations, collected immediately before the leach test began, comprised the fourth leach solution.
4. The four bottles for each of the five sample types, duplicate, and blank samples were filled with the solutions described above. The bottles were filled as follows:

<u>Bottle Number</u>	<u>Solution</u>
1	2.8 pH
2	6.0 pH
3	12.5 pH
4	Organics

5. The sample bottles were equilibrated for 24 hours at constant temperature with an end-over-end tumbler. After that time, the leach solutions were filtered through 0.45 micrometer (μm) filters and split into two portions, A and B.
6. Filtrate portion A was analyzed for pH and dissolved arsenic. Filtrate portion B was acidified to pH <2 with nitric acid and analyzed for dissolved lead.

7.4.3 Results

The results of the leach potential test are presented in Table 7.4-1. The results indicate that leachable lead was detected from all five of the sample material types under test conditions. The leachable lead concentration varied depending on the sample material and on the initial leach solution pH.

The battery casing sample results indicate that the high pH leach solution resulted in the largest concentration of leachable lead (660 mg/l). The results also indicate that there was a small increase in leachable lead concentration in the low pH solution (0.25 mg/l) compared to the moderate pH solution (0.15 mg/l). The results for the high organic leach solution (0.75 mg/l) indicate a small increase in leachable lead concentration compared to the moderate pH solution, which has a comparable solution pH. The high leachable lead concentration measured in the high pH leach solution is probably the result of solubilized lead hydroxides that precipitate at lower pH. Leachable arsenic was detected above the detection limit (0.005 mg/l) in the high organic leach solution (0.027 mg/l) and in the high pH solution (0.007 mg/l).

TABLE 7.4-1

LEACH POTENTIAL TEST RESULTS

Sample Material	Initial Leach Solution pH/TOC	Final Leach Solution pH	Leach Solution Lead Concentration (mg/l)	Leach Solution Arsenic Concentration (mg/l)
Blank	2.8/LOW	2.8	U0.05	U0.005
	6.0/LOW	6.1	U0.05	U0.005
	12.5/LOW	12.3	0.08	U0.005
	6.5/HIGH	6.5	0.11	U0.005
Battery Casing	2.8/LOW	6.8	0.25	U0.005
	6.0/LOW	6.9	0.15	U0.005
	12.5/LOW	12.2	660	0.007
	6.5/HIGH	6.6	0.75	0.027
Sediment	2.8/LOW	6.8	0.13	0.087
	6.0/LOW	6.9	0.12	0.059
	12.5/LOW	11.7	0.13	1.6
	6.5/HIGH	6.6	0.18	0.32
Matte	2.8/LOW	5.8	6.8	U0.005
	6.0/LOW	5.8	9	0.005
	12.5/LOW	6.3	0.23	U0.005
	6.5/HIGH	5.8	5.2	0.008
Subsurface Soil	2.8/LOW	12.3	0.31	U0.005
	6.0/LOW	12.4	0.36	U0.005
	12.5/LOW	12.5	0.46	U0.005
	6.5/HIGH	12.1	0.18	U0.005
Surface Soil	2.8/LOW	5.8	3.1	0.007
	DUPLICATE	5.8	2.7	U0.005
	6.0/LOW	5.9	0.44	U0.005
	DUPLICATE	6.0	0.48	U0.005
	12.5/LOW	11.9	7.9	0.72
	DUPLICATE	11.8	6.3	0.72
	6.5/HIGH	6.2	0.7	0.007
	DUPLICATE	6.3	0.61	U0.005

The sediment sample results indicate that the leachable lead concentrations were approximately the same for each of the four leach solutions, with the high organic solution result (0.18 mg/l) indicating a slight increase over the moderate pH leach solution (0.12 mg/l). The arsenic analyses indicate that the high pH solution resulted in the largest concentration of leachable arsenic (1.6 mg/l). The results also indicate that there was a slight increase in leachable arsenic in the low pH solution (0.087 mg/l) compared to the moderate pH solution (0.059 mg/l). The results for the high organic leach solution (0.32 mg/l) indicate a moderate increase in leachable arsenic concentration compared to the moderate pH solution.

The matte sample results indicate that the leachable lead concentrations in the low pH (6.8 mg/l), moderate pH (9.0 mg/l) and high organic (5.2 mg/l) leach solutions were relatively the same. The high pH leach solution result (0.23 mg/l) is significantly lower, possibly due to adsorption of lead onto iron oxides generated by the high initial pH of the solution (the matte material has very high concentrations of iron). Leachable arsenic results were relatively the same for all four leach solutions, ranging from less than the detection limit (0.005 mg/l) to 0.008 mg/l in the high organic leach solution.

The subsurface soil results indicate that leachable lead concentrations were relatively the same for the low, moderate and high pH solutions (0.31, 0.36, and 0.46, respectively). The high organic leach solution result was slightly lower (0.18 mg/l). There was no detectable arsenic in any of the four leach solutions. The equilibrated pH in all four solutions was greater than 12.0. This is probably due to the very high pH of the soils used for the test.

The surface soil sample test was conducted in duplicate. The results for the sample and the duplicate sample indicate good agreement, with an average percent difference of less than \pm 20 percent. The results indicate that the high pH solution resulted in the largest leachable lead concentration (7.9 mg/l). The results for the low pH leach solution (3.1 mg/l) indicate a significant increase in leachable lead compared to the moderate pH solution (0.48 mg/l). The high organic

solution result (0.70 mg/l) indicates a slight increase over the moderate pH solution. Arsenic concentrations were at or below the detection limit (0.005 mg/l) in the low and moderate pH and high organic leach solutions. The leachable arsenic concentration in the high pH leach solution was 0.72 mg/l.

7.4.4 Conclusions

The following conclusions are based on the results of the leach potential test:

1. Solutions with high initial pH (greater than 11) increase the leachable lead and arsenic concentrations, except where possible scavaging/adsorption by iron oxides may occur.
2. The leachability of lead is apparently enhanced at low pH compared to moderate pH. If the conditions simulated during the test are representative of the site conditions, then lower pH water would have a greater potential for mobilizing lead at the site.
3. Although high organic leach solutions indicated slightly higher leachable lead concentrations in some samples, there is no apparent significant leachable lead enhancement attributable to the organic concentrations used in this test. Therefore, if the high organic solution composition is representative of site water, then organics would probably have no significant effect on lead mobilization at the site.

8.0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

8.1 POTENTIAL RECEPTORS

8.1.1 Humans

8.1.1.1 Demographics Near Site

The study area is largely industrial in nature. The nearest residences are on the hillside to the southwest (see Section 2.1.3). The site has limited access; it is fenced on all sides except for the entrance through the salvage yard (Rhone-Poulenc property) to the west and would be difficult for the casual visitor to enter. While it is unlikely that young persons would play in the area or gain unauthorized access to the Gould property, this possibility cannot be ruled out.

8.1.1.2 Pathways of Contamination

As indicated in Section 3.0, the principal contaminant of concern (lead) and minor secondary contaminants (arsenic, cadmium, chromium and zinc) are present in the surface soil, surface water, pond (Doane Lake remnant) sediments, subsurface soil, and ground water. The presence of these metals in these matrices indicates that exposure may occur through contact, inhalation, ingestion, or any combination of the three. Skin contact with these metals at concentrations observed is highly unlikely to result in a toxic response.

Literature reports show that, in general, arsenic, cadmium, zinc, and chromium exposure in the general population of the United States occurs via inhalation of contaminant-laden dust and/or ingestion of contaminated food and water. Inhalation of tobacco smoke is also a general pathway of exposure to cadmium and arsenic. The major route of inorganic lead absorption is through inhalation and ingestion. The amount of lead actually absorbed will depend upon factors such as age and nutritional status of the individual.

The greatest potential for exposure to those living or working in the vicinity of the site is through inhalation of contaminant-laden

dust. However, exposure by ingestion cannot be ruled out. Dust may settle on surfaces and subsequently be ingested. Further, should these contaminants be absorbed through the consumption of water, adverse health effects would likely occur. Exposure to zinc by inhalation, ingestion, or contact is unlikely to result in an adverse response. The more likely human response associated with zinc is a deficient condition rather than a toxic condition.

8.1.2 Flora and Fauna

8.1.2.1 Endangered Species

The only federally-designated endangered or threatened species with the potential to contact site contaminants is the bald eagle, Haliaeetus leucocephalus (endangered in Oregon, threatened in Washington). Bald eagle distribution in this area is primarily along the Columbia River islands and sloughs during foraging flights. Documented nesting sites occur far to the west of the site in the vicinity of the Columbia River mouth (Becassio, et al. 1981). Bald eagles are typically scavengers, preying upon dead or dying fish. To the extent that a bald eagle may prey upon fish containing elevated levels of lead, zinc, cadmium, or arsenic, they are a potential receptor. However, the probability of this occurrence is very low due to the small number of bald eagles in the area.

8.1.2.2 Pathways of Contamination

Potential receptors among the study area flora and fauna include the plant species growing in the immediate vicinity of contaminated areas, terrestrial species foraging in these areas, and aquatic species inhabiting the Doane Lake remnants. Onsite flora and fauna may be exposed to site contaminants through uptake of contaminated surface water or ingestion of contaminated plant material or pond sediments. Bird species that frequent the Doane Lake remnants will consume surface water and/or surficial sediments. Aquatic insects or other species inhabiting the Doane Lake remnants will probably be exposed to contaminants dissolved in the water column as well as those in surficial sediments.

8.1.2.3 Bioaccumulation of Contaminants

Transfer of contaminants through the food chain and bioaccumulation is possible given the types of organisms observed in the study area. Uptake and accumulation of contaminants, especially metals, by plants growing on site is a potential concern. Though probably not harmful to the plants themselves, the contaminants in their seeds, leaves, and roots could be taken up by small mammals and birds that consume these plant parts. Larger predators, such as hawks and owls, could be exposed to these contaminants through feeding on small mammals and birds. Contaminants may also be incorporated into the leaves of the plants growing on site. Leaves falling from these plants may be carried by wind into the river where they will decompose. During breakdown of the leaf, contaminants would become incorporated into the bottom sediments. Ingestion of sediments by detritivorous aquatic invertebrates that are in turn eaten by fish would provide another pathway of contamination and accumulation.

8.1.2.4 Transfer to Humans

The most likely means of contaminant transfer to humans is through hunting or fishing activities that occur off site. Mallards were observed on site and, since this species is also actively hunted throughout the area, it is potentially possible for one that had been feeding on site to be shot and subsequently consumed by humans. There is little likelihood of any aquatic species in the Doane Lake remnants being consumed by humans since only non-game species are known to inhabit these ponds and access is restricted.

8.2 PUBLIC HEALTH

8.2.1 Human Health Effects of Site Contaminants

8.2.1.1 General

The toxic characteristics of the compounds identified as waste material indicators are described herein. Levels of waste material indicator metals in various matrices taken from the site are identified

in Section 3.0. The information provided below is presented as a general survey of literature reports on possible harmful effects of contaminants observed on site. No instances of any of these effects have been observed on site, nor are these effects expected from exposure to levels of site contaminants that have been measured. This subject will be fully addressed in the Feasibility Study Risk Assessment.

8.2.1.2 Arsenic

Arsenic compounds may be absorbed after ingestion or inhalation. Chronic arsenic poisoning is characterized by malaise and fatigue. Gastrointestinal disturbances and peripheral neuropathy (numbness of extremities) may occur. Acute arsenic poisoning rarely occurs except by accidental or homicidal ingestion. Symptoms consist of dryness of the oral and nasal cavities, vertigo, delirium, and coma.

Arsenic is ubiquitous in distribution in both soil and certain food products. Routine exposure to arsenic leads to a normal body burden of less than 100 milligrams per 70 kilograms of body weight (Doull et al. 1980). The normal body burden will likely be exceeded by exposure to arsenic on the Gould site. The average daily intake of arsenic which would result in the "normal body burden" of less than 100 milligrams per 70 kilograms of body weight is 0.7 milligrams. Ground-water sample number W-02D from sampling round 1 indicates a level of 0.61 milligrams per liter. If one were to drink slightly more than one liter of this water daily, the body burden of arsenic would probably be higher than normal.

Adverse health effects would be dependent upon individual susceptibility, age, and nutritional status. Arsenic is a natural constituent of many foods; seafood, pork, liver, and salt may contain exceptionally high levels of arsenic. Therefore, persons whose diet is high in these foods and who live within the exposure area of the Gould site run a greater risk of developing arsenic-related problems than those with similar diets living outside the exposure area. Young persons may be considered at greater risk than adults because children consume more per unit of body weight than do adults. Thus, children residing in the

exposure area are at greater risk than their cohorts living outside the exposure area. Moreover, smokers are at increased risk because of the high arsenic content of tobacco smoke (Doull, et al. 1980; U.S. EPA 1983b).

8.2.1.3 Cadmium

The principal organs affected by cadmium exposure are the lungs and kidneys. The respiratory symptoms of exposure largely mimic emphysema. The kidney symptoms include increased proteinuria (urine protein). Acute exposure to cadmium via inhalation results in local irritation of the respiratory tract, chest pains, nausea, and dizziness.

The usual sources of cadmium exposure for the general population include food products and tobacco smoke. The foods that accumulate high concentrations are shellfish, liver, and kidney. Dietary intake of these foods among smokers who live in the exposure area puts them at greater risk than cohorts living outside the exposure area. Those living inside the exposure area may exceed the normal cadmium body burden of 30 milligrams per 70 kilograms of body weight. The normal body burden is based on an average daily intake of about 0.1 milligrams (Doull, et al. 1980).

8.2.1.4 Chromium

The toxicity of chromium is related to the type of chromium involved.

Short-term exposure to chromates may cause severe tissue irritation. If ingested, chromates may cause stomach and kidney problems. Long-term exposure may cause tissue ulceration, liver damage and skin rash. An increased incidence of lung cancer has been detected in persons exposed to chromates. The dusts of chromium metal and its insoluble salts are considered to be relatively nontoxic (Occupational Health Guidelines for Chemical Hazards, NIOSH). Chromates are absorbed through the lungs. Dichromates are readily absorbed through the skin.

Trivalent chromium is not metabolized to the hexavalent state and, thus, is not absorbed in the hexavalent state. It probably does not

pose a significant problem.

The normal body burden of chromium is less than 6 milligrams per 70 kilograms of body weight and is based on an average daily intake of 0.06 milligrams (Doull, et al. 1980). The usual exposure to chromium occurs through diet. Brown sugar, animal fats, and butter are high in chromium content. Intake of these foods, along with exposures to onsite chromium, may result in a body burden of chromium in excess of the normal. Children would be more adversely affected because of greater consumption of water per kilogram of body weight (U.S. EPA 1984).

8.2.1.5 Lead

The toxicity of lead will depend on the form in which it is encountered; inorganic lead or organic lead. The primary symptoms of exposure to inorganic lead are dullness, restlessness, irritability, headache, muscular tremor, defective muscular coordination and loss of memory. These symptoms may progress to convulsions, coma and death. Residual damage may include epilepsy, hydrocephalus, and idiocy. The central nervous system is most generally affected by exposure to organic lead compounds. Symptoms may include hallucinations, delusions, and excitement. Ingested lead is usually only 5 to 10 percent absorbed and the balance is excreted in the feces; however, 35 to 50 percent of inhaled lead enters the blood.

When large quantities of lead enter the body over a short period of time, the lead is distributed throughout and causes symptoms of acute poisoning (stupor, coma, death). Symptoms of chronic exposure include cramps, dizziness, weakness, insomnia, diarrhea and loss of appetite.

Since lead is excreted in urine, feces, and to a lesser degree, in the hair and is measured as lead, metabolism plays a small role in detoxification. However, there may be cellular or enzymatic changes which are indicative of impending lead intoxication.

The normal body burden of lead is 120 milligrams per 70 kilograms of body weight and is based on an average daily intake of 0.3 milligrams (Doull, et al. 1980). In the general population the major hazard is for

young children who chew lead-containing paint and eat lead-laden dust. Children are at greater risk because of greater absorption of dietary lead than that which occurs in adults.

8.2.1.6 Zinc

Zinc plays an important role in human enzymes and enzymatic functions, protein synthesis, and carbohydrate metabolism.

Exposure to zinc oxide fumes may cause metal fume fever, a nauseous condition with attendant high fever. The condition is temporary and totally reversible. Zinc is stored in the liver, red blood cells and bone. Zinc is eliminated principally by the gastrointestinal tract. The more likely human response associated with zinc is a deficient condition rather than a toxic condition.

8.2.2 Exposure to Contaminated Areas

8.2.2.1 Review of Pathways of Contamination

The metals of concern discussed in Section 3.1 may enter the body through ingestion and inhalation and, to a lesser degree, by contact. These metals have been identified in the ground water, surface water, surface soil, subsurface soil, and in pond sediments. The potential for inhalation of the contaminants is almost exclusively via airborne dust during hot, dry, and windy days. The potential for ingestion is almost exclusively via consumption of water. These means of exposure will exacerbate symptoms attributable to dietary and other "natural" exposures.

8.2.2.2 Physiological Incorporation of the Contaminant

Arsenic, cadmium, chromium, lead, and zinc are incorporated into the body through absorption into the bloodstream from the lungs and gastrointestinal tract. However, the specific sites of absorption and metabolic fate of each metal is different.

Arsenic is absorbed into the blood from both the lungs and the gastrointestinal tract. Arsenate compounds are rapidly excreted by the

kidneys and probably do not accumulate in tissues. Arsenites accumulate in liver, muscles, hair, nails, and skin. Excretion is via the bile (Doull, et al. 1980; U.S. EPA 1983b).

Cadmium is poorly absorbed from the gastrointestinal tract, but deficiencies in calcium, iron, and protein can enhance cadmium absorption.

Chromates are absorbed rapidly from the lungs while trivalent chromium is poorly absorbed from the gastrointestinal tract. Under normal conditions chromium is stored in the skin, lungs, muscle, and fat. Chromium is primarily excreted in urine (Doull, et al. 1980).

Lead is absorbed through the gastrointestinal tract and through the lungs. Absorption from the gastrointestinal tract is enhanced by dietary deficiency in calcium, iron, fats, and proteins. Lead is stored in bone but will be reabsorbed into the blood when exposure ceases. Excretion is via urine and the bile (Doull, et al. 1980).

Zinc is absorbed through the gastrointestinal tract and through the lungs. Not all the zinc in the diet is absorbed. The liver, kidney, pancreas, and muscle are the primary storage locations for zinc. Excretion is largely through the gastrointestinal tract (Doull, et al. 1980). Zinc deficiency presents a greater health problem than excessive exposure.

8.2.2.3 Applicability to Gould Site

As mentioned at the outset of Section 8.2, this discussion is a general summary of possible human health effects from site contaminants. This subject will be fully addressed in the Feasibility Study Risk Assessment.

8.3 ENVIRONMENTAL IMPACTS

8.3.1 Onsite Environmental Impacts

Environmental impacts to air, water, soil, and biota have occurred on site as a result of past industrial processes and subsequent contamination. This section presents a review of the onsite environmental damage that has been identified through the studies undertaken for the remedial investigation.

The major onsite environmental impact to air quality results from increased levels of airborne, lead-containing particulate material as a result of wind acting on battery piles. Air monitoring results showed that monthly and quarterly average airborne lead values at the site are typically less than 1/2 to 1/3, respectively, of the allowable federal and state air standards, as long as there are no site activities. The primary source of airborne lead stems from entrainment of small particles by the wind blowing over the piles during dry periods. Small particles (≤ 10 micrometers) can be particularly dangerous to humans since they pass through the filtering mechanisms of the upper respiratory tract and enter the lungs. Means of minimizing this impact would include the use of dust suppressants, water sprays, or wind screens during cleanup activities.

Onsite environmental impacts to water include contamination of the ground water, primarily with lead and zinc, as a result of industrial processes and unconfined storage of battery casings. Also, sulfuric acid derived from the crushed batteries has caused the pH of the ground water to be quite low (pH < 4) at the piles. Low pH tends to increase the solubility of lead in water. The pH gradually increases away from the piles due to the buffering effect of natural soil minerals. Thus, dissolved lead contamination decreases as ground water moves toward the site boundaries.

Onsite environmental impacts to soil include contamination of the fill material with lead, arsenic, cadmium, chromium, zinc, and sulfates. Of the 39 subsurface fill samples collected and analyzed, all showed

contamination with at least one of these metals at levels higher than statistical background (Section 4.2.4.3). Samples from areas of battery casing fragments are most highly contaminated with lead. Samples from the alluvium underlying the fill indicate some minor contamination. No samples were collected and chemically analyzed from the basalt layer, but it is not expected to be contaminated due to its depth below the fill material.

The major environmental impact to biota has been the filling of Doane Lake and subsequent elimination of aquatic habitat. Natural sources and drainages were altered or eliminated as a result of this filling. Natural shoreline vegetation was eliminated and replaced with species providing lower quality habitat (e.g., blackberries); in some cases the shoreline remained barren of vegetation. Crushed battery casings used as fill or stored adjacent to the east Doane Lake remnant shoreline have also resulted in contamination of the water column and surficial sediments with various metals, primarily lead.

8.3.2 Off-site Environmental Impacts

Environmental impacts to off-site areas can result from the movement of contaminants through ground water or surface runoff, dust particles in the air, or transfer by animals. This section reviews the off-site environmental damage likely to have occurred. It is based on the results obtained from studies conducted for the remedial investigation, as well as existing information of contaminant transport processes.

Off-site environmental impacts to air quality can result from the transport of contaminant-laden particles by wind. Based on the results described in Section 5.0, likely off-site impacts include the airborne transport and deposition of lead-laden particles during dry, windy periods or during cleanup and removal of the battery casing piles and matte areas. The use of dust suppressants, water sprays, or wind screens could minimize off-site impacts from these events.

Off-site environmental impacts to water quality can result from movement of site contaminants through ground water, overflow runoff

from the east Doane Lake remnant during high water periods, and precipitation runoff. The volume of water carried by the Willamette is such that site runoff is rapidly diluted downstream of the outfall. Inputs of heavy metal contaminants to the Willamette River from other sources exist in the river's lowest reach. These sources add to the contaminant load of the river. Based on the results presented in Section 4.3, likely off-site impacts as a result of overflow runoff from the east Doane Lake remnant to the Willamette River include an incremental increase in heavy metal pollution to the river.

Ground-water movement could transport contaminants (primarily lead) to off-site areas. As discussed in Section 8.3.1, increased pH levels (up to pH 11) of the ground water near the site boundaries decreases the amount of dissolved lead carried by the ground water.

Off-site impacts to soil, based on the results discussed in Section 4.2, are probably minimal. Use of onsite surficial soils as off-site fill material (either in the past or future) could result in contamination in the area where the fill is placed. Removal of contaminated, onsite fill during cleanup activities would transfer the contamination to the disposal site.

Off-site environmental impacts to biota could result from the transport of contaminants through food chains and bioaccumulation. Bird species feeding on site probably ingest contaminants from site vegetation or aquatic insects inhabiting the Doane Lake remnants. These contaminants could be transferred to organisms inhabiting off-site areas through predation or scavenging. The accumulation of site contaminants in the surficial sediments of the Willamette River as a result of site runoff poses some degree of risk to aquatic species in the Willamette River.

9.0 REFERENCES

- American Society for Testing and Materials, 1981. Annual Book of ASTM Standards, Part 19, ASTM D422-63 (Reapproved 1972), page 113.
- _____, 1981. Annual Book of ASTM Standards, Part 19, ASTM D423-66 (Reapproved 1972), page 124.
- _____, 1981. Annual Book of ASTM Standards, Part 19, ASTM D424-59 (Reapproved 1971), page 128.
- _____, 1981. Annual Book of ASTM Standards, Part 19, ASTM D2216-80, page 342.
- _____, 1981. Annual Book of ASTM Standards, Part 19, ASTM D2434-68 (Reapproved 1974), page 368.
- Becassio, A.D., J.S. Isakson, A.E. Redfield, W.M. Blaylock, H.C. Finney, R.L. Frew, D.C. Lees, D. Petrula, and R.D. Godwin, 1981. Pacific Coast ecological inventory. User's guide and information base. Biological Services Program. U.S. Fish and Wildlife Service. Washington, D.C. FWS/OBS-81/30. 159 pp.
- Brown, S.G., 1963. "Problems of Utilizing Ground Water in the West-Side Business District of Portland, Oregon", USGS Water Supply Paper 1619-0, 42 p.
- City of Portland, 1986. Willamette Greenway Update - 1985/86 Background Document, Bureau of Planning, 153 p.
- _____, 1987. Willamette Greenway Update - 1986/86 Recommendations Document, Recommendations to the Planning Commission, Bureau of Planning, 315 p.
- Dames & Moore, 1981. "Factual Report Phase II Geohydrological and Waste Management Investigation, Portland, Oregon, for Rhone-Poulenc, Inc." (12088-002-04).
- _____, 1982a. "Factual Report Groundwater Monitoring Program, Portland Plant Site, Portland, Oregon, for Gould, Inc." (11831-006-04).
- _____, 1982b. "Preliminary Report Phase II Geohydrologic and Waste Management Investigation, Portland, Oregon, for Rhone-Poulenc, Inc." (12088-002-04).
- _____, 1984. "Geotechnical Investigation, Cornell Road Bridge Project, Portland, Oregon for Multnomah County" (10908-007-04).
- _____, 1987. "Laboratory Data Supplement, Draft Remedial Investigation Report, NL/Gould Site, Portland, Oregon" (11831-034-05).
- Davies, P.H. and W.H. Everhard, 1973. Effects of chemical variations in aquatic Environments. Vol. III "Lead Toxicity to Rainbow Trout and Testing Application Factor Concept: EPA-R3-73-011C.

- Doull, J., C.D. Klaassen, and M.O. Amdur, 1980. Casarett and Doull's Toxicology. The basic science of poisons. MacMillan Publishing Co. New York, New York.
- FEMA, 1982. Flood Insurance Rate Map (FIRM), City of Portland, Oregon; Panel 15. Federal Emergency Management Agency.
- _____, 1986. Flood Insurance Rate Map (FIRM), City of Portland, Oregon; Panel 20, 1986, Federal Emergency Management Agency.
- Franklin, J.F. and C.T. Dyrness, 1973. Natural vegetation of Oregon and Washington. U.S. Department of Agriculture, Pacific Northwest forest and range experimental station, Portland, Oregon. General Technical Report PNW-8. 417 pp.
- Freeze, B.A. and J.A. Cherry, 1979. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.
- Haji-Djafari, S., P.E. Antommarid and H.L. Crouse, 1981. Attenuation of Radionuclides and Toxic Elements by In-Situ Soils at a Uranium Tailings Pond in Central Wyoming. In: Permeability and Groundwater Contaminant Transport, ASTM STP746, T.F. Zimmie and C.O. Riggs, Eds., American Society for Testing and Materials.
- Hart, C.L. and R.C. Newcomb, 1965. Geology and Ground Water of the Tualatin Valley, Oregon. Geological Survey Water-Supply Paper 1967. U.S. Government Printing Office, Washington, D.C.
- Hogenson, G.M. and B.L. Foxworthy, 1965. Ground water in the east Portland area, Oregon. U.S. Geological Survey Water-Supply Paper 1793.
- Hines, W.G., S.W. McKenzie, D.A. Rickert, and F.A. Rinella, 1977. Dissolved-oxygen regimen of the Willamette River, Oregon, under conditions of basinwide secondary treatment. USGS Circular 715-I. 152 p.
- Hvorslev, J., 1951. "Time Lag and Soil Permeability in Groundwater Observations", Waterways Experiment Station Bulletin No. 36, U.S. Army Corps of Engineers.
- METRO, 1985. Population and Housing by Census Tract, Portland Metropolitan Area, April 1985. Intergovernmental Resource Center, Metropolitan Service District. Portland, Oregon.
- Moore, Gene, Gould Site Caretaker, 1986a. Personal communication with J.E. Pyne, Dames & Moore.
- _____, Gould Site Caretaker, 1986b. Personal communication with W.M. Blaylock, Dames & Moore.
- _____, Gould Site Caretaker, 1987. Personal communication with M.W. Anderson, Dames & Moore.

- Mundorff, M.J., 1964. Geology and Ground-Water Conditions of Clark County, Washington, with a Description of a Major Alluvial Aquifer Along the Columbia River. Geological Survey Water-Supply Paper 1600. U.S. Government Printing Office, Washington, D.C.
- _____, 1981. Letter to M.E. Elmore, President, Gould, Inc. Metals Division, dated October 30.
- Oregon Department of Environmental Quality (DEQ), 1982. Portland area water quality toxics investigation. Unpub. data from DEQ internal files. Portland, OR.
- _____, 1985. Analyses of water samples collected October 31, 1985. Unpublished data from DEQ internal files. Portland, Oregon.
- Oregon Department of Fish and Wildlife, 1972. Unpublished field data for gill-net sampling between the Willamette River mouth and Ross Island Bridge. Oregon Department of Fish and Wildlife, Clackamas, Oregon.
- _____, 1986. Unpublished field data for electroshocker sampling in the lower Willamette River within Portland Harbor. Oregon Department of Fish and Wildlife, Clackamas, Oregon.
- Pavlik, H.F. and D.D. Runnells, 1984. Determination of distribution coefficients appropriate for modeling contaminant migration from energy residual wastes. Envir. Chem. of Oil Shale Develop. Report No. DOE/ER/60-121-2, U.S. Dept. Energy, Office Energy Res. Washington, D.C. pp. 19-38.
- Relyea, J.F., Serne, R.J. and D. Rai, 1980. Methods for determining radionuclide retardation factors: status report. Report PNL-3349, UC-70, PNW Lab. Richland, Washington. pp 27.
- Rickert, D.A., W.G. Hines and S.W. Mackenzie, 1976a. "Methodology for River-Quality Assessment with Application to the Willamette River Basin in Oregon", USGS Circular 715-M, 55 p.
- _____, 1976b. Project development and data programs for assessing the quality of the Willamette River, Oregon, USGS Circular 715-C. 31 p.
- Rickert, D.A., V.C. Kennedy, S.W. McKenzie, and W.G. Hines, 1977. A synoptic survey of trace metals in bottom sediments of the Willamette River, Oregon. River quality assessment of the Willamette River basin. U.S. Department of the Interior. U.S. Geological Survey. Circular 715-F. 27 pp.
- Ruffner, James A., 1985. Climates of the States, Third Edition, Volume II. Gale Research Company, Detroit, Michigan.
- Schlicker, H.G. & R.J. Deacon, 1964. "Earthquake Geology, Portland", State of Oregon, Department of Geology & Mineral Industries, Ore Bin, December 1964, pp. 209-230.

- Schock, M.R. and M.C. Gardels, 1983. Plumbosolvency reduction by high pH and low carbonate-solubility relationships. Journal AWWA, Vol. 75, pp 87-91.
- Stiger, Clint, 1987. National Weather Service, Portland, Oregon, personal communication with C.F. Kienle, Dames & Moore.
- Todd, D.K., 1980. Ground-water Hydrology, 2nd Edition, John Wiley & Sons, New York.
- Treasher, R.C., 1942. "Geologic History of the Portland Area", State of Oregon Department of Geology and Mineral Industries, GMI Short Paper No. 7, 15 pp.
- Trimble, D.E., 1963. "Geology of Portland, Oregon and Adjacent Areas", USGS Bulletin 1119.
- U.S. EPA, 1982. Letter from Mr. P. Wong, EPA Region X, to Mr. C.R. Clinton, Oregon DEQ, dated October 27.
- _____, 1983a. "Report of the Dallas Area Lead Assessment Study", U.S. E.P.A. Lead Smelters Group Office of Toxics Integration.
- _____, 1983b. Health Assessment Document for Inorganic Arsenic. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina.
- _____, 1984. Health Assessment Document for Chromium. Final Report. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina. PB85-115905.
- Willamette Week, 1985. "Portland's Toxic Armpit", by Garret Romaine, Vol. 11, No. 4, August 8-14, 1985.
- Wright, T.L., D.A. Swanson, R.T. Helz and G.R. Byerly, 1979. "Major Oxide, Trace Element and Glass Chemistry of Columbia River Basalt Samples Collected Between 1971 and 1977", USGS Open-file Report 79-711.

10.0 GLOSSARY

Adsorption: The attraction of adhesion of a layer of ions from an aqueous solution to the solid mineral surfaces with which it is in contact.

Advection: The process by which solutes are transported by the motion of flowing ground water.

Acid: Any chemical compound containing hydrogen capable of being replaced by positive elements or radicals to form salts. In terms of the dissociation theory, it is a compound which, on dissociation in solution, yields excess hydrogen ions. Acids lower the pH. Examples of acids or acidic substances are hydrochloric acid, tannic acid, and sodium acid pyrophosphate.

Alkaline: Any of various soluble mineral salts found in natural water and arid soils having a pH greater than 7. In water analysis, it represents the carbonates, bicarbonates, hydroxides, and occasionally the borates, silicates, and phosphates in the water.

Alluvium: A general term for all detrital deposits (clay, silt, sand, gravel, or similar unconsolidated material) resulting from the operations of modern rivers, thus including the sediments laid down in river beds, flood plains, lakes, fans at the foot of mountain slopes, and estuaries.

Anion: A negatively charged ion that migrates to an anode, as in electrolysis.

Anion exchange: Ion exchange process in which anions in solution are exchanged for other anions from an ion exchanger.

Anisotropic: Showing different physical properties with regard to transmission (in this case) of ground water between the vertical and horizontal directions.

Annulus: The space between the drill string or casing and the wall of the borehole or outer casing.

Antecedent moisture: The soil moisture present before a particular precipitation event.

Aquiclude: A saturated, but poorly permeable bed, formation, or group of formations that does not yield water freely to a well or spring. However, an aquiclude may transmit appreciable water to or from adjacent aquifers.

Aquifer: A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs.

Aquifer, confined: An aquifer that is overlain by a confining bed. The confining bed has a significantly lower hydraulic conductivity than the aquifer.

Aquifer, unconfined: An aquifer in which there are no confining beds between the zone of saturation and the surface. There will be a water table in an unconfined aquifer. Water-table aquifer is a synonym.

Aquifer test: A test involving the withdrawal of measured quantities of water from or addition of water to, a well and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or addition.

Aquitard: A geologic formation, group of formations, or part of a formation through which virtually no water moves.

Artificial recharge: Recharge at a rate greater than natural, resulting from deliberate actions of man.

Atterburg Limits: a collective term including liquid limit, plastic limit, and plasticity index.

Bar: A mass of sand, gravel, or alluvium deposited on the bed of a stream, sea, or lake, or at the mouth of a stream.

Barrier boundary: An aquifer-system boundary represented by a rock mass that is not a source of water.

Base exchange: The displacement of a cation bound to a site on the surface of a solid, as in silica-alumina clay-mineral packets, by a cation in solution.

Baseflow: That part of stream discharge derived from ground water seeping into the system.

Baseflow recession: The declining rate of discharge of a stream fed only by baseflow for an extended period. Typically, a baseflow recession will be exponential.

Baseflow-recession hydrograph: A hydrograph that shows a baseflow-recession curve.

Bentonite: A colloidal clay, largely made up of the mineral sodium montmorillonite, a hydrated aluminum silicate.

Bioassay: A method used to determine the toxicity of specific contaminants. A number of individuals of a sensitive species are placed in water containing varying concentrations of the contaminant for a specified period of time.

Bridge: An obstruction in the drill hole or annulus. A bridge is usually formed by caving of the wall of the well bore, by the intrusion of a large boulder, or by filter pack materials during well completion. Bridging can also occur in the formation during well development.

Capillary forces: The forces acting on soil moisture in the unsaturated zone, attributable to molecular attraction between soil particles and water.

Capillary fringe: The zone immediately above the water table, where water is drawn upward by capillary attraction.

Cation: An ion having a positive charge and, in electrolytes, characteristically moving toward a negative electrode.

Cation exchange: Ion exchange process in which cations in solution are exchanged for other cations from an ion exchanger.

Chemical activity: The molal concentration of an ion multiplied by a factor known as the activity coefficient.

Common ion effect: The decrease in the solubility of a salt dissolved in water already containing some of the ions of the salt.

Cone of depression: A depression in the ground-water table or potentiometric surface that has the shape of an inverted cone and develops around a well from which water is being withdrawn. It defines the area of influence of a well.

Contaminant: Any solute that enters the hydrologic cycle through human action.

Darcy's law: A derived equation for the flow of fluids on the assumption that the flow is laminar and that inertia can be neglected.

Density: Mass per unit volume expressed in pounds per gallon (lb/gal), pounds per cubic ft (lb/ft³), and kilogram per cubic m (kg/m³).

Depression storage: Water from precipitation which collects in puddles at the land surface.

Development: The act of repairing damage to the formation caused by drilling procedures and increasing the porosity and permeability of the materials surrounding the intake portion of the well.

Discharge: Rate of flow at a given instant in terms of volume per unit of time.

Discharge area: An area in which there are upward components of hydraulic head in the aquifer. Ground water is flowing toward the surface in a discharge area and may escape as a spring, seep, or baseflow, or by evaporation and transpiration.

Discharge velocity: An apparent velocity, calculated from Darcy's law, which represents the flow rate at which water would move through an aquifer if the aquifer were an open conduit. Also called specific discharge.

Dispersion: The spreading and mixing of chemical constituents in ground water caused by diffusion and mixing due to microscopic variations in velocities within and between pores.

Dissociation: A chemical process that causes a molecule to split into simpler groups of atoms, single atoms, or ions. For example, the water molecule (H_2O) breaks down spontaneously into H^+ and OH^- ions.

Drawdown: A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping of ground water from wells.

Drilling fluid: A water- or air-based fluid used in the water-well drilling operation to remove cuttings from the hole, to clean and cool the bit, to reduce friction between the drill string and the sides of the hole, and to seal the borehole.

Duration curve: A graph showing the percentage of time that the given flows of a stream will be equaled or exceeded. It is based upon a statistical study of historic streamflow records.

Effective porosity: The amount of interconnected pore space through which fluids can pass, expressed as a percent of bulk volume. Part of the total porosity will be occupied by static fluid being held to the mineral surface by surface tension, so effective porosity will be less than total porosity.

Effluent: A waste liquid discharge from a manufacturing or treatment process, in its natural state or partially or completely treated, that discharges into the environment.

Electrical conductance: A measure of the ease with which conducting current can be caused to flow through a material under the influence of an applied electric field. It is the reciprocal of resistivity and is measured in mhos per foot (meter).

Electrolyte: A chemical which dissociates into positive and negative ions when dissolved in water, increasing the electrical conductivity.

Equilibrium constant: The number defining the conditions of equilibrium for a particular reversible chemical reaction.

Equipotential line: A line in a two-dimensional ground-water flow field such that the total hydraulic head is the same for all points along the line.

Equipotential surface: A surface in a three-dimensional ground-water flow field such that the total hydraulic head is the same everywhere on the surface.

Equivalent weight: The concentration in part per million of a solute multiplied by the valence charge and then divided by its formula weight in grams.

Field capacity: The maximum amount of water that the unsaturated zone of a soil can hold against the pull of gravity. The field capacity is dependent on the length of time the soil has been undergoing gravity drainage.

Flow net: The set of intersecting equipotential lines and flowlines representing two-dimensional steady flow through porous media.

Flow, steady: The flow that occurs when, at any point in the flow field, the magnitude and direction of the specific discharge are constant in time.

Flow, unsteady: The flow that occurs when, at any point in the flow field, the magnitude or direction of the specific discharges changes with time. Also called transient flow or nonsteady flow.

Fluid potential: The mechanical energy per unit mass of fluid at any given point in space and time.

Fluvial: Of or pertaining to a river or rivers; produced by the action or a stream or river--the term is used by geologists especially in regard to river flow and river action.

Free energy: A measure of the thermodynamic driving energy of a chemical reaction. Also known as Gibbs free energy or Gibbs function.

Frenchman Springs: A stratigraphic division (Member) of the Columbia River Basalt Group. The basalt under the study area is thought to belong to the Frenchman Springs.

Ground water: The water contained in interconnected pores located below the water table in an unconfined aquifer or located in a confined aquifer.

Ground-water flow: The movement of water through openings in sediment and rock which occurs in the zone of saturation.

Hardness: A measure of the amount of calcium, magnesium, and iron dissolved in the water.

Head loss: The part of head energy which is lost because of friction as water flows.

Head, total: The sum of the elevation head, the pressure head, and the velocity head at a give point in an aquifer.

Heterogeneous: Pertaining to a substance having different characteristics everywhere. A synonym is nonuniform.

Homogeneous: Pertaining to a substance having identical characteristics everywhere. A synonym is uniform.

Horizontal permeability: Hydraulic conductivity in a horizontal direction.

Hvorslev's equation: An equation for the calculation of in-situ horizontal permeabilities.

Hydration: The act by which a substance takes up water by absorption and/or adsorption.

Hydraulic conductivity: The rate of water flow, in gallons per day, through a one square foot cross-section of a permeable medium under a unit hydraulic gradient. The density and kinematic viscosity of the water must be considered in determining hydraulic conductivity.

Hydraulic gradient: The change in total head with a change in distance in a given direction. The direction is that which yields a maximum rate of decrease in head.

Hydrochemical facies: Bodies of water with separate, but distinct, chemical compositions contained in an aquifer.

Hydrodynamic dispersion: The process by which ground water containing a solute is diluted with uncontaminated ground water as it moves through an aquifer.

Hydrogeologic: Those factors the deal with subsurface waters and related geologic aspects of surface waters.

Hydrograph: A graph that shows some property of ground water or surface water as a function of time.

Hydrologic equation: An expression of the law of mass conservation for purposes of water budgets. It may be stated as inflow equals outflow plus or minus changes in storage.

Hydrometer: Indicates the method of determining percent of particle size smaller than 53 microns (#270 sieve size).

Hydrostratigraphic unit: A formation, part of a formation, or a group of formations in which there are similar hydrologic characteristics allowing for grouping into aquifers or confining layers.

Hygroscopic water: Water that clings to the surfaces of mineral particles in the zone of aeration.

Infiltration: The flow of water downward from the land surface into and through the upper soil layers.

Infiltration capacity: The maximum rate at which infiltration can occur under specific conditions of soil moisture. For a given soil, the infiltration capacity is a function of the water content.

Injection well: A well drilled and constructed in such a manner that water can be pumped into an aquifer in order to recharge it.

Interflow: The lateral movement of water in the unsaturated zone during and immediately after a precipitation event. The water moving as interflow discharges directly into a stream or lake.

Intermediate zone: That part of the unsaturated zone below the root zone and above the capillary fringe.

Intrinsic permeability: Pertaining to the relative ease with which a porous medium can transmit a liquid under a hydraulic or potential gradient. It is a property of the porous medium and is independent of the nature of the liquid or the potential field.

Ion: An element or compound that has gained or lost an electron, so that it is no longer neutral electrically, but carries a charge.

Ion exchange: A process by which an ion in a mineral lattice is replaced by another ion which was present in an aqueous solution.

Isocon: A line drawn on a map to indicate equal concentrations of a solute in ground water.

Isohyetal line: A line drawn on a map, all points along which receive equal amounts of precipitation.

Isotropic: Having the same properties the same in all directions.

Laminar flow: That type of flow in which the fluid particles follow paths that are smooth, straight, and parallel to the channel walls. In laminar flow, the viscosity of the fluid damps out turbulent motion. Compare to turbulent flow.

Law of mass action: The law stating that for a reversible chemical reaction the rate of reaction is proportional to the concentrations of the reactants.

Leachate: The liquid that has percolated through solid waste and dissolved soluble components.

Leaky confining layer: A low-permeability layer that can transmit water at sufficient rates to furnish some recharge to a well pumping from an underlying aquifer. Also called aquitard.

Lense: Discontinuous layer that is relatively thick in the center and tapers at each end and disappears.

Liquid Limit: The moisture content of a soil at the point of transition between the plastic and semiliquid states.

Metamorphic rocks: Any rock derived from pre-existing rocks by mineralogical, chemical, and/or structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment, generally at depth in the Earth's crust.

Molality: A measure of chemical concentration. A one-molal solution has one mole of solute dissolved in 1,000 grams of water. One mole of a compound is its formula weight in grams.

Molecular diffusion: Dispersion of a chemical caused by the kinetic activity of the ionic or molecular constituents.

Molecule: A stable configuration of atomic nuclei and electrons bound together by electrostatic and electromagnetic forces. It is the simplest structural unit that displays the characteristic physical and chemical properties of a compound.

Naturally developed well: A well in which the screen is placed in direct contact with the aquifer materials; no filter pack is used.

Nominal: Used to describe standard sizes for pipe from 1/8 inch to 12 inch (3.2 mm to 305 mm). The nominal size is specified on the basis of the inside diameter. Depending on the wall thickness, the inside diameter may be less than or greater than the number indicated.

Observation well: A well drilled in a selected location for the purpose of observing parameters such as water levels and pressure changes.

Overland flow: The flow of water over a land surface due to direct precipitation. Overland flow generally occurs when the precipitation rate exceeds the infiltration capacity of the soil and depression storage is full.

Oxidation: The combining of element with oxygen.

Perched water: Unconfined ground water separated from an underlying main body of ground water by an unsaturated zone.

Percolate: The act of water seeping or filtering through the soil without a definite channel.

Permeability: The property or capacity of porous rock, sediment, or soil for transmitting a fluid; it is a measure of the relative ease of fluid flow under unequal pressure.

pH: A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. Originally stood for the words potential of hydrogen.

Phreatic water: Water in the zone of saturation.

Piezometer: A nonpumping well, generally of small diameter, which is used to measure the elevation of the water table or potentiometric surface. A piezometer generally has a short well screen through which water can enter.

Piezometer nest: A set of two or more piezometers set close to each other but screened to different depths.

Plastic limit: The water content of a soil at the point of transition between the semisolid and plastic states.

Plasticity index: The percent difference between moisture content of a soil at the liquid and plastic limits.

Pleistocene: The earlier of the two epochs comprising the Quaternary Period. Some geologists use Quaternary and Pleistocene synonymous, implying that the glacial age is still with us.

Polymer: A substance formed by the union of two or more molecules of the same kind linked end to end into another compound having the same elements in the same proportion but a higher molecular weight and different physical properties.

Pore space: The volume between mineral grains in a porous medium.

Porosity: The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment.

Potentiometric surface: A surface that represents the level to which water will rise in tightly cased wells. If the head varies significantly with depth in the aquifer, then there may be more than one potentiometric surface. The water table is a particular potentiometric surface for an unconfined aquifer.

Pumping cone: The area around a discharging well where the hydraulic head in the aquifer has been lowered by pumping. Also called cone of depression.

Pumping test: A test made by pumping a well for a period of time and observing the change in hydraulic head in the aquifer. A pumping test may be used to determine the capacity of the well and the hydraulic characteristics of the aquifer. Also called aquifer test.

Radial flow: The flow of water in a aquifer toward a vertically oriented well.

Radius of influence: The radial distance from the center of a well bore to the point where there is no lowering of the water table or potentiometric surface (the edge of its cone of depression).

Recharge: The addition of water to the zone of saturation; also, the amount of water added.

Recharge basin: A basin or pit excavated to provide a means of allowing water to soak into the ground at rates exceeding those that would occur naturally.

Recharge boundary: An aquifer system boundary that adds water to the aquifer. Streams and lakes are typical recharge boundaries.

Recovery: The rise in water level in pumping well and nearby observation wells after ground-water discharge has ceased.

Redox: A chemical reaction in which an atom or molecule loses electrons to another atom or molecule. Also called oxidation-reduction. Oxidation is the loss of electrons; reduction is the gain in electrons.

Residual drawdown: The difference between the original static water level and the depth to water at a given instant during the recovery period.

Runoff: The total amount of water flowing in a stream. It includes overland flow, return flow, interflow, and baseflow.

Saturated zone: The zone in which the voids in the rock or soil are filled with water at a pressure greater than atmospheric. The water table is the top of the saturated zone in an unconfined aquifer.

Seepage velocity: The actual rate of movement of fluid particles through porous media.

Sieve analysis: Determination of the particle-size distribution of a soil, sediment, or rock by measuring the percentage of the particles that will pass through standard sieves of various sizes.

Slug test: An aquifer test made by either pouring a small instantaneous charge of water into a well or by withdrawing a slug of water from the well.

Soil moisture: The water contained in the unsaturated zone.

Solubility product: The equilibrium constant that describes a solution of a slightly soluble salt in water.

Specific capacity: The rate of discharge of a water well per unit of drawdown, commonly expressed in gpm/ft or m³/day/m. It varies with duration of discharge.

Specific electrical conductance: The ability of water to transmit an electrical current. It is related to the concentration and charge of ions present in the water.

Specific gravity: The weight of a particular volume of any substance compared to the weight of an equal volume of water at a reference temperature.

Specific weight: The weight of a substance per unit volume. The units are newtons per cubic meter.

Specific yield: The ratio of the volume of water that is given mass of saturated rock or soil will yield by gravity to the volume of that mass. This ratio stated as a percentage.

Stagnation point: A place in a ground-water flow field at which the ground water is not moving. The magnitude of vectors of hydraulic head in the point are equal but opposite in direction.

Static water level: The level of water in a well that is not being affected by withdrawal of ground water.

Storage, specific: The amount of water released from or taken into storage per unit volume of a porous medium per unit change in head.

Storativity: The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. It is equal to the product of specific storage and aquifer thickness. In an unconfined aquifer, the storativity is equivalent to the specific yield. Also called storage coefficient.

Storm hydrograph: A graph of the discharge of a stream over the time period when, in addition to direct precipitation, overland flow, interflow, and return flow are adding to the flow of the stream. The storm hydrograph will peak due to the addition of these flow elements.

Stream, gaining: A stream or reach of a stream, the flow of which is being increased by inflow of ground water. Also known as an effluent stream.

Stream, losing: A stream or reach of a stream that is losing water by seepage into the ground. Also known as an influent stream.

Stringer: Thin, usually irregular masses of material interbedded or interdispersed within larger masses (i.e., flows or irregular-thin deposits).

Throughflow: The lateral movement of water in an unsaturated zone during and immediately after a precipitation event. The water from throughflow seeps out at the base of slopes and then flows across the ground surface as return flow, ultimately reaching a stream or lake.

Total dissolved solids (TDS): A term that expresses the quantity of dissolved material in a sample of water, either the residue on evaporation, dried at 356°F (180°C), or, for many waters that contain more than about 1,000 mg/l, the sum of the chemical constituents.

Transmissivity: The rate at which water of a prevailing density and viscosity is transmitted through a unit width of an aquifer or confining bed under a unit hydraulic gradient. It is a function of properties of the liquid, the porous media, and the thickness of the porous media.

Transpiration: The process by which water absorbed by plants, usually through the roots, is evaporated into the atmosphere from the plant surface.

Turbidity: Cloudiness in water due to suspended and colloidal organic and inorganic material.

Turbulent flow: That type of flow in which the fluid particles move along very irregular paths. Momentum can be exchanged between one portion of the fluid and another.

Uniformity coefficient: A numerical expression of the variety in particle sizes in mixed natural soils, defined as the ratio of the sieve size on which 40 percent (by weight) of the material is retained to the sieve size on which 90 percent of the material is retained.

Unsaturated zone: The zone between the land surface and the water table. It includes the root zone, intermediate zone, and capillary fringe. The pore spaces contain water at less than atmospheric pressure, as well as air and other gases. Saturated bodies, such as perched ground water, may exist in the unsaturated zone. Also called the vadose zone.

Vadose water: Water in the zone of aeration.

Vertical permeability: Hydraulic conductivity in a vertical direction.

Viscosity: The property of a fluid describing its resistance to flow. Units of viscosity are newton-seconds per meter squared or pascal-seconds.

Water content: The ratio of the volume of soil moisture to the total volume of the soil. This is the volumetric water content, also called volume wetness.

Water table: The surface in an unconfined aquifer or confining bed at which the pore water pressure is atmospheric.

Weathering: The in-situ physical disintegration and chemical decomposition of rock materials at or near the Earth's surface.

Well, fully penetrating: A well drilled to the bottom of an aquifer, constructed in such a way that it withdraws water from the entire thickness of the aquifer.

Well interference: The result of two or more pumping wells, the drawdown cones of which intercept. At a given location, the total well interference is the sum of the drawdowns due to each individual well.

Well, partially penetrating: A well constructed in such a way that is draws water directly from a fractional part of the total thickness of the aquifer. The fractional part may be located at the top or the bottom or any where in between the aquifer.

Well screen: A filtering device used to keep sediment from entering a water well.

Well yield: The volume of water discharged from a well in gallons per minute or cubic meters per day.

FEASIBILITY STUDY
GOULD SITE
PORTLAND, OREGON

VOLUME I
TEXT

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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1.0 INTRODUCTION	1-1
1.1 OBJECTIVE AND OVERVIEW	1-3
1.2 SITE BACKGROUND INFORMATION	1-3
1.2.1 Site Location and Description	1-3
1.2.2 History, Operation, and Regulatory Action	1-3
1.2.3 Community Concerns	1-13
1.3 NATURE AND EXTENT OF PROBLEM	1-14
1.3.1 Contaminants Detected	1-14
1.3.2 Extent and Migration of Contaminants.....	1-15
1.3.2.1 Surface Soils, Subsurface Soils, and Sediments.....	1-15
1.3.2.2 Battery Casings and Matte.....	1-19
1.3.2.3 Surface Water.....	1-23
1.3.2.4 Ground Water.....	1-25
1.3.2.5 Contaminant Transport	1-46
1.3.3 Risks to Human Health and the Environment	1-56
1.4 OBJECTIVES OF REMEDIAL ACTION	1-57
2.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES.....	2-1
2.1 SCREENING CRITERIA AND METHODOLOGY	2-2
2.1.1 Remedial Objectives.....	2-2
2.1.2 Contaminant Characteristics and Site Conditions..	2-2
2.2 IDENTIFICATION OF GENERAL RESPONSE ACTIONS	2-4
2.2.1 No Action.....	2-4
2.2.2 Control of Airborne Contaminant Migration.....	2-4
2.2.3 Control of Surface Contamination	2-7
2.2.4 Control of Subsurface Contamination	2-7
2.2.5 Control of Contaminant Migration in Surface Water.....	2-7
2.2.6 Control of Contaminant Migration in Ground Water.....	2-8
2.2.7 Institutional Controls.....	2-8
2.3 IDENTIFICATION AND SCREENING OF TECHNOLOGIES	2-8
2.3.1 No Action	2-8
2.3.2 Surface Treatment Technologies	2-19
2.3.2.1 Paving or Capping	2-19
2.3.2.2 Fixation/Stabilization	2-21
2.3.2.3 Revegetation	2-22
2.3.2.4 Installation of Wind Fences or Screens	2-23

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
2.3.3 Soil, Sediment and Matte Treatment Technologies	2-23
2.3.3.1 Fill Excavation for Treatment/Disposal	2-24
2.3.3.2 Surface Soil, Subsurface Soil, Sediment and Matte	2-27
2.3.3.2.1 On-Site Treatment: Fixation/Stabilization	2-28
2.3.3.2.2 On-Site Treatment: Soil Washing/Leaching.....	2-31
2.3.3.2.3 In-Situ Treatment	2-33
2.3.3.3 Battery Casings	2-34
2.3.3.3.1 Recycle of Casing Materials..	2-34
2.3.3.3.2 Incineration of Casing Materials.....	2-41
2.3.4 Water Treatment Technologies	2-43
2.3.4.1 Ground-Water Removal for Treatment	2-43
2.3.4.2 Control of Ground-Water Migration	2-44
2.3.4.3 Water Treatment	2-46
2.3.5 Disposal Options	2-51
2.3.5.1 Disposal of Fill Materials	2-51
2.3.5.1.1 On-Site Disposal	2-51
2.3.5.1.2 Off-Site Disposal	2-52
2.3.5.1.3 Disposal of Treated Water and Sludge	2-52
2.3.6 Institutional Controls	2-54
2.3.6.1 Well Permit Restrictions	2-54
2.3.6.2 Site Access Restrictions	2-54
2.3.6.3 Land Use Restrictions	2-55
2.3.6.4 Deed Restrictions	2-55
2.3.6.5 Sale Restrictions	2-55
2.4 SUMMARY OF REMEDIAL TECHNOLOGIES	2-56
3.0 DEVELOPMENT AND SCREENING OF THE PRELIMINARY ALTERNATIVES ...	3-1
3.1 DEVELOPMENT OF PRELIMINARY REMEDIAL ALTERNATIVES	3-2
3.2 SCREENING OF THE PRELIMINARY REMEDIAL ALTERNATIVES	3-12
3.3 FINAL CANDIDATE ALTERNATIVES	3-27

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
4.0 DESCRIPTION OF FINAL CANDIDATE ALTERNATIVES	4-1
4.1 ALTERNATIVE 1	4-2
4.2 ALTERNATIVE 2A	4-5
4.3 ALTERNATIVE 2B	4-9
4.4 ALTERNATIVE 8	4-13
4.5 ALTERNATIVE 10	4-17
4.6 ALTERNATIVE 21	4-28
4.7 ALTERNATIVE 25	4-36
5.0 ENGINEERING STUDIES	5-1
6.0 DETAILED EVALUATION OF THE FINAL REMEDIAL ALTERNATIVES	6-1
6.1 DESCRIPTION OF EVALUATION CRITERIA	6-2
6.1.1 Effectiveness	6-3
6.1.1.1 Endangerment Assessment	6-4
6.1.1.1.1 Introduction	6-4
6.1.1.1.2 Methods	6-4
6.1.1.2 Reliability	6-5
6.1.1.3 Conformance to ARARs	6-5
6.1.1.4 Reduction in Toxicity, Mobility, or Volume.....	6-6
6.1.2 Implementability	6-6
6.1.2.1 Technical Feasibility	6-6
6.1.2.1.1 Constructability.....	6-6
6.1.2.1.2 Performance	6-6
6.1.2.1.3 Safety	6-7
6.1.2.1.4 Time Required	6-7
6.1.2.2 Administrative Feasibility	6-7
6.1.2.2.1 Permitting Requirements	6-7
6.1.2.2.2 Community Concerns	6-8
6.1.2.2.3 Institutional Requirements...	6-8
6.1.2.3 Availability.....	6-8
6.1.3 Cost Analysis	6-8
6.1.3.1 Capital Costs	6-8
6.1.3.2 Annual Operation and Maintenance Costs..	6-9
6.1.3.3 Present Worth	6-10
6.1.3.4 Sensitivity Analysis.....	6-10

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
6.2 ALTERNATIVE 1 EVALUATION	6-11
6.2.1 Effectiveness	6-11
6.2.2 Implementability	6-13
6.2.3 Cost Analysis	6-15
6.3 ALTERNATIVE 2A EVALUATION	6-15
6.3.1 Effectiveness	6-15
6.3.2 Implementability	6-17
6.3.3 Cost Analysis	6-19
6.4 ALTERNATIVE 2B EVALUATION	6-19
6.4.1 Effectiveness	6-20
6.4.2 Implementability	6-22
6.4.3 Cost Analysis	6-24
6.5 ALTERNATIVE 8 EVALUATION	6-25
6.5.1 Effectiveness	6-25
6.5.2 Implementability	6-27
6.5.3 Cost Analysis	6-30
6.6 ALTERNATIVE 10 EVALUATION	6-30
6.6.1 Effectiveness	6-31
6.6.2 Implementability	6-33
6.6.3 Cost Analysis.....	6-36
6.7 ALTERNATIVE 21 EVALUATION	6-38
6.7.1 Effectiveness	6-38
6.7.2 Implementability	6-40
6.7.3 Cost Analysis	6-43
6.8 ALTERNATIVE 25 EVALUATION	6-44
6.8.1 Effectiveness	6-44
6.8.2 Implementability.....	6-46
6.8.3 Cost Analysis	6-49
6.9 SUMMARY OF DETAILED EVALUATION OF ALTERNATIVES	6-49

TABLE OF CONTENTS (Concluded)

<u>Section</u>	<u>Page</u>
7.0 SUMMARY OF ALTERNATIVES	7-1
7.1 SUMMARY OF THE FINAL CANDIDATE ALTERNATIVES	7-1
7.2 RECOMMENDED REMEDIAL ALTERNATIVE	7-8
8.0 REFERENCES	8-1

APPENDICES

Appendix

A	ENDANGERMENT ASSESSMENT
B	ENGINEERING STUDIES
C	BREAKDOWN OF CAPITAL AND OPERATING COSTS
D	EMISSIONS MODELS
E	AIR MONITORING DURING FS
F	CORRESPONDENCE

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1.2-1	General Vicinity Map	1-4
1.2-2	Study Area Location Map	1-5
1.2-3	History of Fill on the Site	1-6
1.3-1	Surface Soil and Sediment Secondary Source Location Map	1-16
1.3-2	Approximate Waste Disposal Locations and Battery Casings Test Pit and Sampling Locations	1-18
1.3-3	Matte Test Pit Locations	1-22
1.3-4	Sulfate and Dissolved Lead Plumes, Fill Aquifer	1-40
1.3-5	Sulfate and Dissolved Lead Plumes, Upper Alluvial Aquifer	1-42
1.3-6	Sulfate and Dissolved Lead Plumes, Lower Alluvial Aquifer	1-45
2.3-1	Soils Leaching System	2-32
2.3-2	Hydro-Classification System	2-36
2.3-3	Heavy Media Separation	2-38
2.3-4	Incineration System	2-43
4.2-1	Extent of Remedial Activity Under Alternatives 2A and 2B	
4.2-2	Existing Land Use and Zoning Code Designations	4-10
4.4-1	Extent of Remedial Activity Under Alternative 8	4-16
4.5-1	Soils Treatment Facility	4-20
4.5-2	Battery Casing Treatment Facility	4-22
4.5-3	Ebonite Treatment Plant	4-23

LIST OF TABLES

<u>Table</u>		<u>Page</u>
1.2-1	Chronological History of Gould Site Operations	1-8 thru 1-12
1.3-1	Composition of Battery Casing Samples Collected from Surface Piles on Gould Property	1-19
1.3-2	Prepared Battery Casing Sample Analysis Results	1-20
1.3-3	Battery Casing Sample Composition by Weight (Percent Dry Weight)	1-21
1.3-4	Matte Analysis Results	1-23
1.3-5	Summary of Chemical Analyses, Subsurface Samples of Alluvium	1-29
1.3-6	Ground Water - Round 1 (August - September 1986), Round 2 (December 1986 - January 1987), and Round 3 (February 1987) Analysis Results	1-30 thru 1-32
1.3-7	Statistical Evaluation of Ground-Water Chemistry Results, Rounds 1, 2, and 3	1-33 thru 1-35
1.3-8	Federal Standards for Metals	1-39
1.3-9	Airborne Lead Concentrations Daily Averages	1-52 thru 1-54
1.3-10	Airborne Lead Concentrations Monthly and Quarterly Averages	1-55
2.2-1	General Response Action Categories and Associated Remedial Technologies	2-4
2.3-1	Remedial Action Technologies Applicable to the Gould Site	2-9 thru 2-18
2.4-1	Remedial Action Technologies Applicable to the Gould Site	2-57 thru 2-67
3.1.1	Remedial Technologies Applicable to the Site Fill	3-5
3.1-2	Combination of the Applicable Technologies into Preliminary Remedial Options	3-6
3.1-3	Preliminary Remedial Options	3-8 thru 3-10
3.1-4	Remedial Options for Surface Water and Ground Water	3-11
3.2-1	Chemical-Specific ARARs for the Gould Site	3-14
3.2-2	Relative Ranking of the Preliminary Remedial Options	3-20
3.2-3	Estimated Quantities of Site Fill Materials, Used for Developing Preliminary Cost Estimates	3-22
3.2-4	Preliminary Unit Costs for Remedial Option Technologies	3-23
3.2-5	Final Remedial Options for Surface Water and Ground-Water Treatment	3-38

LIST OF TABLES (Continued)

<u>Table</u>	<u>Page</u>
3.3-1 List of the Final Candidate Alternatives	3-39
3.3-2 Final Candidate Alternatives	3-40
3.3-3 List of Final Candidate Alternatives	3-41 thru 3-43
5.2-1 Battery Casing Coating Test Results	5-3
5.3-1 Batch Adsorption Test Results	5-7 thru 5-9
5.3-2 Calculation Summary Table	5-11
5.4-1 Leach Potential Test Results	5-15
5.5-1 TLCP Leach Test Results	5-19
5.6-1 Source Materials After Separation	5-21
5.6-2 Results of Plastic and Ebonite Treatments	5-22
5.7-1 Test Results from Poly-Cycle Industries Equipment	5-25
5.8-1 Results of United Scrap Lead Ball Mill Washings	5-27
5.8-2 Results of Sonic Cleaning and Soaking of Battery Casings	5-27
6.1-1 Criteria for the Detailed Evaluation of the Alternatives	6-3
6.9-1 Summary of Cost Estimates	6-51
6.9-2 Summary of Effectiveness Evaluation	6-52
6.9-3 Summary of the Implementability Evaluation	6-54
7.1-1 Summary of the Detailed Evaluation of the Final Candidate Alternatives	7-2

Section 1.0 of the report contains introductory material to allow the reader to become familiar with site contaminants and the history of site operations and regulatory interactions. A statement of the objectives of remedial action at the Gould site is also presented.

Section 2.0 identifies and screens the remedial technologies potentially applicable to the site. The screening criteria and methodology are discussed and general response actions are presented. The section ends with a summary of the applicable technologies.

Section 3.0 outlines the combination of technologies into preliminary remedial alternatives. The criteria for screening these preliminary remedial alternatives are discussed and subsequently used to reduce the number of alternatives to seven, which are evaluated in detail in subsequent sections.

Section 4.0 contains a detailed description of the features of each of the Final Candidate Alternatives developed in Section 3.0.

Section 5.0 presents the results of several engineering studies that were performed to evaluate the applicability of certain technologies to site problems.

Section 6.0 presents the detailed evaluation of the final candidate alternatives. The evaluation factors are presented, as well as the results of the evaluation for effectiveness, implementability, and cost. The results of the endangerment assessment are also summarized for each alternative.

Section 7.0 summarizes the remedial alternatives and recommends a single alternative, based on the results of the detailed evaluation.

Section 8.0 identifies references and source documents used in preparing the Feasibility Study.

Appendices to this report include:

- Appendix A - Endangerment Assessment
- Appendix B - Engineering Studies
- Appendix C - Breakdown of Capital and Operating Costs
- Appendix D - Correspondence
- Appendix E - Air Monitoring During the FS

1.2 SITE BACKGROUND INFORMATION

1.2.1 Site Location and Description

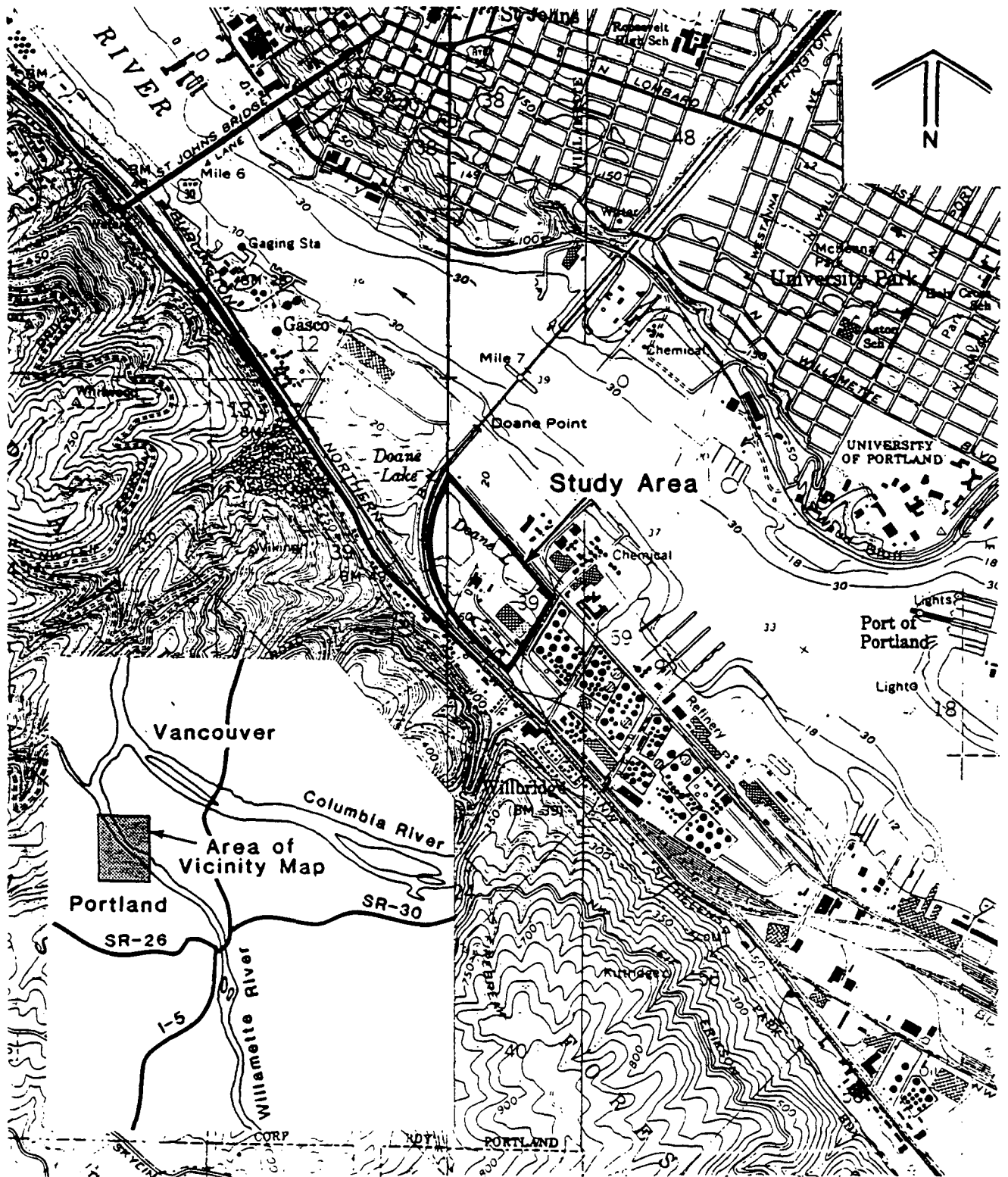
Gould site is located in the Doane Lake area of Portland between N.W. St. Helens Road and N.W. Front Avenue, about 1.3 miles southeast of St. John's Bridge. As shown on Figure 1.2-1 (General Vicinity Map), the Willamette River lies about 1,000 feet to the northeast and flows northwest, parallel to Front Avenue. The area is heavily industrialized. The Gould property encompasses 9.2 acres and is only a portion of the 60-acre study area, as shown on Figure 1.2-2 (Study Area Location Map).

The study area encompasses all of the former (1949) areal extent of Doane Lake. Although it is roughly bounded on the southwest by N.W. St. Helens Road, on the northeast by N.W. Front Avenue, on the southeast by 61st Street, and on the west and northwest by the Burlington Northern railroad right-of-way, the study area was not entirely confined to these boundaries. Industrial properties adjacent to Gould that lie wholly or partly within the study area include American Steel Industries, Inc.; ESCO Corporation; Rhone-Poulenc Inc.; Northwest Equipment Rentals, Inc. (formerly Atlas Wrecking, leased from Rhone-Poulenc); Schnitzer Investment Corporation, Liquid Air Corporation (leased from Schnitzer); and Pennwalt Corporation.

1.2.2 History, Operation, and Regulatory Action

Available aerial photographs taken since 1936, and topographic mapping as early as 1884, indicate that the study area now occupied by Gould property and adjacent industries was formed by gradual and intermittent filling of a fairly large body of shallow water known as Doane Lake (Figure 1.2-3).

Prior to development (as indicated by aerial photographs taken in 1936 and 1940) the brush- and grass-covered landfill on the Gould site extended into and rose a few feet above Doane Lake. An aerial photograph taken on June 1, 1948, shows the presently existing railroad spur coming onto the western edge of the plant site. The secondary lead smelting facility was completed and went into operation in 1949 under the ownership of Morris P. Kirk and Sons (Kirk & Sons), a subsidiary of NL Industries, Inc. At that time, a significant portion of the site was still occupied by Doane Lake. Subsequent expansion consisted of a warehouse constructed in 1950 and a lead oxide building constructed in 1965. Facility operations consisted of lead-acid battery recycling, lead smelting and refining, zinc alloying and casting, cable sweating



0 0.5 1
SCALE IN MILES

NL IND, INC./GOULD, INC.
FEASIBILITY STUDY

GENERAL VICINITY MAP

FIG. 1.2-1

DAMES & MO

11831-034

SCOEPAA00004346

(removal of lead sheathing from copper cable), and (after 1965) lead oxide production.

Available records from the Oregon Department of Environmental Quality (DEQ) for the period between February 1960 and January 1970 indicate that Kirk & Sons received 14 complaints and/or violations regarding emissions from the facility. A January 29, 1970 report by the Columbia-Willamette Air Pollution Authority expressed concern over levels of lead in the vicinity of Morris P. Kirk, and the potential threat to health caused by continued plant operations.

NL Industries, Inc. purchased the property from the subsidiary in 1971. Three violations for excessive emissions were recorded in 1972. Lead was detected in Doane Lake in 1973, and NL Industries was cited for improper wastewater discharge into the lake. On July 30, 1973, NL Industries curtailed all smelting operations, but the lead oxide still, cable sweater, and refining kettles continued to operate. Available records indicate that the facility operated in compliance with DEQ guidelines during 1974 through 1976.

The property was sold by NL Industries to Gould, Inc. in January 1979. In October of the same year, Gould stopped receiving lead-acid batteries, but continued to process a substantial existing stockpile of batteries. In January 1980, lead refining operations were discontinued. Battery decasing operations ceased on April 1, 1981, lead oxide production ceased in May 1981, and the facility closed entirely in August 1981. By the summer of 1982, most of the structures, facilities, and equipment had been removed.

Alchem Western, Inc., began setting up equipment on the Gould property in late 1983 for the purpose of washing, separating, and reclaiming plastic fragments and lead oxide. Battery casing fragments were dredged from the Doane Lake remnant on the northeast portion of the Gould site and stockpiled along the shoreline. These surface debris piles have since remained at this location. After a brief period of activity, Alchem Western suspended operations due to mechanical problems (Moore 1986). Although most of the Alchem Western equipment has been removed, some still remains on the Gould property at the date of this report.

A historical sequence of significant events and actions related to the battery recycling and secondary lead smelting facility is presented in Table 1.2-1.

TABLE 1.2-1

CHRONOLOGICAL HISTORY OF GOULD SITE OPERATIONS

Sheet 1 of 5

1936 & 1940	Aerial photographs (no exact date) show the secondary lead smelting site as a vacant grassy landfill projecting into and rising only a few feet above Doane Lake. The date and source of the pre-1936 landfill are unknown.
June 1, 1948	Aerial photograph shows railroad spur coming into the proposed plant site. No other construction is evident yet.
1949	Secondary lead smelting facility constructed and operated by Morris P. Kirk and Sons (Kirk & Sons). At this time, NL Industries owned 51 percent of Morris P. Kirk (Moore 1986).
1950	Lead oxide building constructed by Kirk & Sons.
Feb. 4, 1960	Complaint mentioned in Oregon Department of Environmental Quality (DEQ) files against Kirk & Sons, regarding burning of battery casings.
1965	A lead oxide production facility was constructed and began operations.
1966	Kirk & Sons initiated a respirator program for employees.
April 14, 1966	The Air Quality Control Division (AQC) of the Portland Bureau of Health recommended taking ambient air lead samples around the Kirk & Sons facility.
July 7, 1966	The AQC observed heavy emissions of yellow dust for 10 minutes around the Kirk & Sons facility.
Dec. 15, 1966	The AQC observed the baghouse stack emitting an opacity reading of 2 to 3 on the Ringleman scale.
Jan. 24, 1967	The AQC reported a 27-minute opacity violation from a 30-minute observation; grayish smoke emission from smelter stack.
Sept. 6, 1967	The AQC reported a 21-1/4-minute opacity violation from a 27-minute observation, white metal fumes and smoke from the blast furnace baghouse stack. The AQC recommended a first notice letter being sent to Kirk & Sons with steps to prevent recurrence of emissions.
Oct. 12, 1967	The Portland Regional Air Pollution Authority noted a 17-minute opacity violation from a 20-minute observation; white to brown smoke from a baghouse stack.

TABLE 1.2-1 (Continued)

Oct. 13, 1967	The AQC observed an opacity violation from the baghouse stack at 16:00 to 16:45 hours.
Oct. 21, 1967	The Portland Regional Air Pollution Authority reported a 27-minute opacity violation from a 30-minute observation; smoke from baghouse stack.
Dec. 26, 1968	The Columbia-Willamette Air Pollution Authority reported a 30-minute violation from a 30-minute observation; smoke and flames from lead sweat furnace stack.
March 31, 1969	The Columbia-Willamette Air Pollution Authority noted a 15-minute violation from a 15-minute observation; smoke from baghouse exhaust stack.
Nov. 14, 1969	Kirk & Sons corrected baghouse emissions from melting kettle and blast furnace.
Jan. 29, 1970	The Columbia-Willamette Air Pollution Authority calculated lead emissions from the Kirk & Sons facility and concluded: "It is apparent that levels of lead in the vicinity of Morris P. Kirk can cause a definite threat to health and should not be allowed to continue."
March 16, 1970	The Columbia-Willamette Air Pollution Authority observed a 16-minute violation from a 16-minute observation; yellow particulates from lead furnace baghouse exhaust.
June 17, 1970	The Columbia-Willamette Air Pollution Authority observed a 5-minute violation from 30-minute observation; gray smoke from stack.
1971	NL Industries purchased the property from their subsidiary, Morris P. Kirk & Sons. Also, this same year battery manufactures began using plastic for casings.
March 16, 1972	The Columbia-Willamette Air Pollution Authority observed a 30-minute violation from a 30-minute observation; white air contaminants from baghouse exhaust. Notice of violation sent to NL Industries; no penalty levied.
Aug. 16, 1972	The Columbia-Willamette Air Pollution Authority noted emissions but recorded no measurements.

TABLE 1.2-1 (Continued)

Sheet 3 of 5

Sept. 27, 1972	The Columbia-Willamette Air Pollution Authority recorded a 49-minute violation from a 60-minute observation; white smoke from baghouse stack. Notice of violation issued, no penalty levied.
March 12, 1973	The DEQ sampled NL facility discharge into Doane Lake; test results indicated 9.5 and 10.3 ppm lead.
March 19, 1973	NL Industries cited for wastewater discharge to Doane Lake.
April 30, 1973	The Columbia-Willamette Air Pollution Authority requested that NL Industries provide a compliance schedule to control emissions from the blast furnace before issuing a new Air Contaminant Discharge Permit. Monitoring and reporting provisions were also a requirement.
July 30, 1973	NL Industries curtailed all smelting operating and remodeled the Portland facility to function as a transfer point to ship and receive goods from Los Angeles. The lead oxide still, cable sweater, and refining kettles continued to operate.
Nov. 6, 1974	Inspection by DEQ indicated that NL Industries was in compliance with its Air Contaminant Discharge Permit.
Jan. 19, 1976	Inspection by DEQ again indicated that NL Industries was in compliance with its Air Contaminant Discharge Permit.
Oct. 1976	Violations for wastewater discharge by NL Industries were corrected.
Jan. 16 & 30, 1978	NL Industries sent two loads of acid waste to a hazardous waste management facility in Arlington, Oregon for disposal.
Aug. 15, 1978	Doane Lake (east remnant) sampled by DEQ; test results indicated 0.1 and 0.3 ppm lead.
Jan. 1979	Gould Inc. purchased the facility from NL Industries.
Oct. 1979	Gould stopped receiving lead-acid batteries for recycling and concentrated on reducing their on-site stockpile.
Nov. 8, 1979	Preliminary modeling analysis by DEQ suggested Gould may be violating the new ambient lead standard for the lead trailer loading operation.

TABLE 1.2-1 (Continued)

Sheet 4 of 5

Jan. 1, 1980	Gould began neutralizing waste acid with ammonia and discharging it into the City sanitary sewer system.
Jan. 1980	Gould terminated lead refining operations.
March 5, 1981	DEQ issued notice to Gould of discharge violations and creating offensive conditions. A medium-rate civil penalty was recommended.
April 1, 1981	Gould terminated battery decasing operation.
April 28, 1981	DEQ obtained two yard-cleaning samples; EP leachate test results indicated 280 and 4,200 ppm lead.
May 1981	Gould terminated lead oxide production.
June through Sept. 1981	Ambient air monitoring conducted at the Gould facility by DEQ.
July 10, 1981	DEQ sent notice to Gould of intent to assess civil penalties.
Aug. 1981	Gould facility ceased all operations.
Oct. 30, 1981	DEQ requested that Gould undertake a comprehensive cleanup program.
Jan. 21, 1982	Dames & Moore began field work on initial monitoring wells.
Feb. 12, 1982	Gould sold plant equipment and buildings.
July 9, 1982	DEQ requested a cleanup program from Gould.
July 22, 1982	DEQ decided no cleanup of the Gould site was warranted by the ground-water data received to date.
Aug. 1982	Dames & Moore conducted one week of ambient air monitoring at the Gould facility.
Sept. 24, 1982	DEQ requested that Gould submit a schedule for removing the battery cases from the site and for sampling soil and pond sediments on the site.
Oct. 26, 1982	Gould responded to DEQ request, indicating that they would level and cover the battery casings.

TABLE 1.3-1 (Concluded)

Sheet 5 of 5

Dec. 3, 1982	DEQ rejected Gould's plan for covering the battery casings.
Feb. 25, 1983	Gould Inc. submitted a letter to EPA objecting to EPA's Hazard Ranking System (HRS) score for the site (see Appendix D). The score had been used by EPA to propose inclusion of the site on the NPL. In particular, the Gould letter objected to the methods used to determine airborne contaminant hazards at the site.
Dec. 31, 1983	Alchem Western moved battery casing recovery equipment to the Gould facility.
Jan. 28, 1984	The Alchem Western equipment operated for one day before experiencing bearing failure. Operations were discontinued and not reinitiated.
Aug. 30, 1985	Gould Inc. and NL Industries signed Section 106, Administration Order on Consent for the Remedial Investigation/Feasibility Study (RI/FS) of the facility.
April 1, 1986	Work Plan for RI/FS by Dames & Moore was approved and site investigations began.
June 1, 1987	Draft RI report was submitted to agencies.
July 29, 1987 and Oct. 1, 1987	Review comments on Draft RI report received from agencies.
Nov. 16, 1987	Final RI report submitted to agencies.

Agency files reviewed: The Oregon Department of Environmental Quality (DEQ) and U.S. Environmental Protection Agency (EPA).

1.2.3 Community Concerns

Relatively few community concerns have been expressed about the Gould site, even though the site has received some media coverage. In 1983, Oregon congressional representative Les AuCoin corresponded with DEQ about the site, and DEQ held a meeting with city, county, and state agency officials to present information about environmental concerns in the area and to solicit comments. Through 1985, neither DEQ nor EPA received inquiries or comments from the public or from employees working in the area (Camp Dresser & McKee, Inc. 1985).

The low level of community involvement may result partly from the absence of residential property nearby. In addition, the Doane Lake area is an established industrialized section of the city, and some segments of the community may view industrial developments as having some degree of unavoidable environmental degradation associated with them. In the Community Relations Plan for the site, Camp Dresser & McKee suggested that interest in the Gould site might increase significantly if the RI/FS revealed serious environmental damage or health hazards and if the site's condition were perceived to adversely affect the long-term economic growth of the area.

The Community Relations Plan identified several issues of concern to the affected community and local officials, including:

1. Ground-water Pollution. People were concerned about ground-water contamination in the area and how it might affect future growth of the area.
2. Airborne Lead. Several agency officials indicated that high levels of lead emissions were a primary concern and that high levels of airborne lead could adversely affect the health of nearby workers. Exposure to lead at the approximately 10 houses in the hills above the site was thought unlikely, but necessary to investigate.
3. Effects on Workers' Health. Individuals were concerned about exposure through incidental ingestion of ground water obtained for industrial use and exposure to airborne lead.
4. Clean-up Schedule. Staff from Representative AuCoin's office and a representative from the Oregon State Public Interest Research Group expressed dissatisfaction that clean-up measures had not been implemented earlier.

5. Future Development of the Doane Lake Area. The media and local officials expressed concern about how the current pollution would affect or restrict future uses of the land.
6. Disposal of Dredged Materials from the River. A representative from the Port of Portland indicated the Port's concern about disposing of dredged materials from the Willamette River that might be found to contain contaminants from the site.
7. Environmental Investigation of Doane Lake Area. A representative from the Association of Oregon Industries and representatives of elected officials indicated concern that DEQ's environmental investigation in the Doane Lake area could decrease future industrial development and jobs in the community.
8. Disposal of Battery Casings. An aide to Representative AuCoin's office expressed dissatisfaction that battery casings had not been removed from the site. Representatives from the Portland Department of Public Works cautioned that any plan to dispose of waste materials at St. Johns' Landfill would be unpopular.

1.3 NATURE AND EXTENT OF PROBLEM

1.3.1 Contaminants Detected

Data developed during the RI show the contaminants detected in each of several media at the Gould site. Of primary importance is the presence of lead in each of the media. Of lesser importance is the presence of other metals in specific media.

In materials from certain ground-water monitoring wells, organic constituents were identified as organic halogenated compounds. However, these organic halogenated compounds were also found in materials collected from upgradient background monitoring wells at concentrations equal to and higher than in materials from the on-site wells. This finding is accepted as evidence for an off-site origin of the organic contamination. No consideration has been given to remediating the effects of these organic compounds in the FS.

1.3.2 Extent and Migration of Contaminants

Contaminated media at the Gould site include surface soils, subsurface soils, lake sediments, surface water, and groundwater. In addition, primary source materials remain on site, including battery casings and matte.

The quantity of surface soils, subsurface soils, and sediments considered to be secondary sources were estimated by using total lead and EP Toxicity data obtained during the RI. An effort was made to correlate the total lead and EP Toxicity values such that total lead may be used for estimating the amount of these secondary source materials that would fail an EP Toxicity value of 5.0 mg/l. Such a relationship was difficult to obtain; however, after comparing the total soil lead concentrations to the corresponding EP Toxicity data, an assumed total soil lead concentration of 3,000 mg/kg was estimated to be the limit below which the EP Toxicity leachate concentration would be below 5.0 mg/l. Samples with total lead concentrations above 3,000 mg/kg were used to indicate secondary source areas.

The correlation used during this FS has importance only for estimation purposes. In practice, should an alternative be chosen which requires cleanup of contaminated secondary source materials, the actual EP Toxicity values of the materials would be obtained and used as indicators of remaining contamination.

1.3.2.1 Surface Soils, Subsurface Soils, and Sediments

The highest surface soil total lead concentrations were detected in samples collected on the Gould property and on the adjacent Rhone-Poulenc property. Figure 1.3-1 shows the areas of surface soil that were identified as secondary source areas using the above total lead criteria and the following assumptions: (1) the depth of the secondary source material was assumed to be 1-foot; and (2) the horizontal extent of the material was assumed to be 50-feet in any direction from the sample locations with total lead concentration above 3,000 mg/kg. Using these assumptions, the quantity of surface soil on the Gould property considered a secondary source is approximately 2,400 cu yds. The quantity on the Rhone-Poulenc property is approximately 970 cu yds.

The highest subsurface soil total lead concentrations were detected in samples collected from the W-7S boring, in the battery casing material. The total lead results for samples collected 2-feet below the bottom of the battery casing material in W-7S indicate that the total

lead concentration decreases to below 1,000 mg/kg (Section 4.2). Based on this result, we assume that the 3,000 mg/kg isopleth for lead in subsurface soil would be reached approximately 1 foot below the casings and matte. Therefore, the subsurface soils considered secondary sources are the soils within one foot of the bottom and sides of the battery casing material buried on the Rhone-Poulenc and Gould properties. The horizontal extent of these two battery casing disposal areas is shown on Figure 1.3-2. The secondary source subsurface soils consist of the following:

1. One foot of soil below the entire area of the battery casing/matte excavations. This would amount to 4,300 cu yds from the area on Rhone-Poulenc property and 5,000 cu yds from the area on the Gould property; and,
2. One foot of soil from the sides of the excavations. Assuming average excavation depths of 20-feet on the Rhone-Poulenc property and 25-feet on the Gould property, and an excavation side-slope ratio of 2:1, this would amount to approximately 2,170 cu yds from the Rhone-Poulenc property and 2,180 cu yds from the Gould property.

The highest sediment total lead concentrations were detected in the east Doane Lake remnant. The areas considered secondary sources are shown on Figure 1.3-1. Based on an assumed depth of 1-foot, the quantity of material would be approximately 5,500 cu yds.

The total quantity of soil considered secondary source material is summarized below:

<u>TYPE AND LOCATION</u>	<u>QUANTITY (cu yds)</u>	
<u>Surface Soil</u>		
Gould property	2,400	
Rhone-Poulenc property	970	
Surface Soil Total	3,370	3,370
<u>Subsurface Soil</u>		
Gould property	5,000	
Bottom Sides	2,180	
Sub-total	7,180	
Rhone-Poulenc property	4,300	
Bottom Sides	2,170	
Sub-total	6,470	
Subsurface Soil Total	13,650	13,650
<u>Sediment</u>		
East Doane Lake Remnant	5,500	
Sediment Total	5,500	5,500
Secondary Source Total	22,520	22,520

1.3.2.2 Battery Casings and Matte

The battery casings consist of hard rubber (ebonite) and plastic casings, metallic lead and lead oxides. At various times during the project, battery casing samples were collected from surface piles, from surface debris on the Gould property, and from the subsurface fill on the Rhone-Poulenc property. From the surface piles, samples were collected at four locations, BC-1 through BC-4 (Figure 1.3-2). Three samples were collected at each location: 1) at the surface; 2) at a depth of 5 feet below the surface; and 3) at the approximate depth of the ground surface (beneath the pile). The samples were non-homogeneous and required preparation before analysis. The battery casing samples were prepared by hand-picking plastic pieces larger than 2 inches and lead and non-lead metal pieces larger than 1/4-inch from the sample to be prepared. The weight of these hand-picked materials, which were not included in the sample analysis, are presented for each sample in Table 1.3-1. The weight of rock/slag was measured, the rock/slag was recombined with the sample, and then the sample was crushed/ground to less than 9-millimeter particle size and homogenized. An aliquot of this homogenized sample was analyzed. Table 1.3-2 presents the results of the prepared sample analyses.

TABLE 1.3-1

COMPOSITION OF BATTERY CASING SAMPLES COLLECTED
FROM SURFACE PILES ON GOULD PROPERTY

Sample #	Hard Rubber	Plastic	Metallic Lead	Lead Oxides	Non-Lead Metal	Rock/ Slag	Moisture
1	16.35	17.65	0.01	4.86	0.36	59.86	0.90
2	40.89	31.37	0.52	9.35	0.00	16.51	1.36
3	56.79	26.86	1.07	10.82	0.00	0.00	4.47
4	62.22	15.38	1.48	6.00	0.00	10.69	4.24
5	52.87	23.99	1.97	12.49	0.00	4.02	4.66
6	52.81	13.86	1.58	10.40	0.00	16.78	4.57
7	54.18	22.63	2.24	13.70	0.00	4.24	3.01
8	54.57	25.75	3.40	10.64	0.00	1.32	4.32
9	55.97	24.94	1.26	11.63	0.00	0.82	5.39
Avg.	49.63	22.49	1.50	9.99	0.04	12.69	3.66

TABLE 1.3-2

PREPARED BATTERY CASING SAMPLE ANALYSIS RESULTS

SAMPLE NUMBER/ LOCATION	DEPTH ¹	Total Lead (mg/kg)	EP Lead (mg/l)	EP Arsenic (mg/l)	EP Chromium (mg/l)	EP Cadmium (mg/l)
BC-1	Surface	60,000	160	U0.2 ⁽²⁾	U0.1	U0.05
	5 feet	140,000	21	U0.2	U0.1	U0.05
	Ground ⁽¹⁾	16,000	220	U0.2	U0.1	0.06
BC-2	Surface	7,600	200	U0.2	U0.1	U0.05
	5 feet	180,000	140	U0.2	U0.1	U0.05
	Ground	130,000	100	U0.2	U0.1	U0.05
BC-3	Surface	190,000	190	U0.2	U0.1	U0.05
	5 feet	160,000	220	U0.2	U0.1	U0.05
	Ground	170,000	120	U0.2	U0.1	U0.05
BC-4	Surface	15,000	200	U0.2	U0.1	U0.05
	5 feet	34,000	130	U0.2	U0.1	U0.05
	Ground	24,000	81	U0.2	U0.1	U0.05

(1) Ground sample collected at a depth approximately equal to the projected ground surface.

(2) U = Less than.

The results for total lead indicate that the lead concentrations (mostly lead oxide) in the prepared battery casing samples ranged from 7,600 mg/kg (0.76 percent) to 190,000 mg/kg (19 percent). All of the samples had EP Toxicity results for lead above the regulatory limit (EP Toxicity limit = 5.0 mg/l). These values ranged from 21 mg/l to 220 mg/l. The data indicate that there was no apparent correlation between total lead concentration and EP Toxicity leachate lead concentration for these samples. The EP Toxicity results for arsenic, chromium, and cadmium indicate that these contaminants were not detected in the EP leachates.

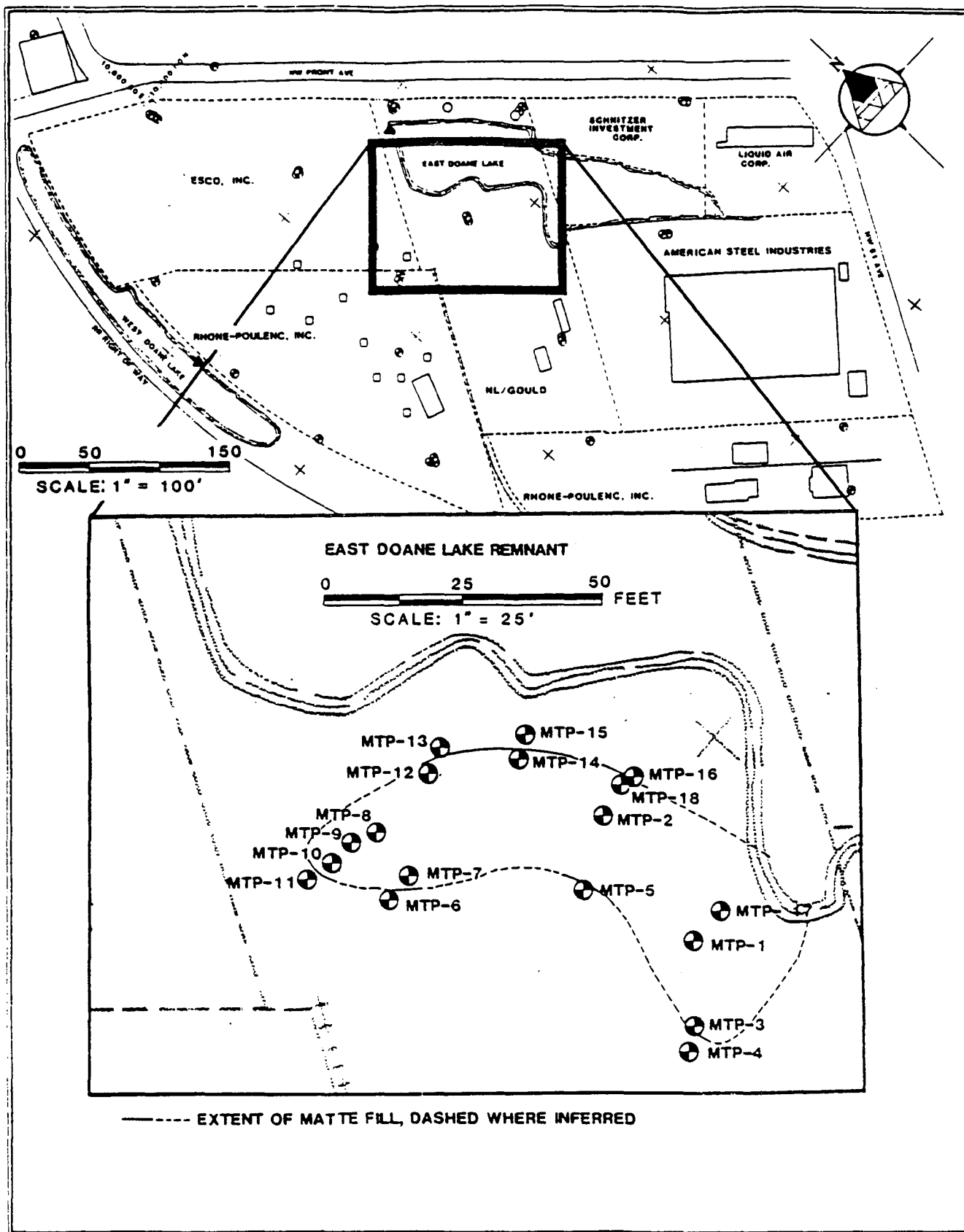
During excavation for engineering studies, a total of 14 battery casing samples were collected, six from Gould surface debris and eight from the Rhone-Poulenc subsurface. The samples were analyzed in a manner similar to the samples from the surface piles. The analytical results are shown in Table 1.3-3. The results in Tables 1.3-1 and 1.3-3 show that the materials from the three locations vary markedly in composition. The surface piles contain a high percentage of plastic relative to materials from surface debris on the Gould property or from the Rhone-Poulenc property. Significantly, the metallic lead and plastic content of subsurface casings on the Rhone-Poulenc property is essentially zero.

TABLE 1.3-3

BATTERY CASING SAMPLE COMPOSITION BY WEIGHT (PERCENT DRY WEIGHT)

	Ebonite	Plastic	Metallic Lead	Lead Oxide/ Dirt/Mud	Rock/ Slag	Other
Gould						
1	87.2	2.6	0.2	9.1	--	0.9
2	84.5	2.7	0.1	12.6	--	--
3	79.3	5.5	2.4	12.7	--	0.1
4	44.0	6.4	4.5	35.2	2.1	7.8
5	86.9	11.6	0.5	--	0.1	0.9
6	88.6	7.7	0.4	3.3	--	--
Avg.	78.4%	6.1%	1.1%	12.2%	0.4%	1.6%
Rhone-Poulenc						
1	89.6	0.6	--	9.8	--	--
2	80.8	--	--	9.6	9.6	--
3	99.6	0.3	--	0.1	--	--
4	73.7	0.5	--	11.5	--	14.3
5	61.4	0.1	0.1	20.9	17.6	--
6	69.5	0.1	--	24.3	6.1	--
7	69.6	0.2	--	20.7	9.5	--
8	80.9	0.3	--	8.0	10.6	0.2
Avg.	78.1%	0.3%	<0.1	13.1%	6.7%	1.8%

The matte materials consist of metallic sulfide chunks primarily containing iron and lead. Matte samples were collected from four of the matte test pit locations: MTP-1, MTP-5, MTP-7 and MTP-8 (Figure 1.3-3).



NL IND, INC./GOULD, INC.
FEASIBILITY STUDY

MATTE TEST PIT LOCATIONS

FIG. 1.3-3

DAMES & MOO

11831-034

SCOEPAA00004360

The samples were collected at depths ranging from 0.5 feet to 3.0 feet below ground surface. The samples were prepared by crushing/grinding the metallic chunks to less than 9-mm particle size and then homogenizing each sample before analysis. The results for the analyses of the matte samples are presented in Table 1.3-4.

TABLE 1.3-4

MATTE ANALYSIS RESULTS

SAMPLE NUMBER	SAMPLE LOCATION	DEPTH (ft)	pH	Total Lead (mg/kg)	EP Lead (mg/l)	EP Arsenic (mg/l)	EP Chromium (mg/l)	EP Cadmium (mg/l)
MT-1	MT-1	1.0	5.2	92,000	12	U0.01	U0.1	0.04
MT-2	MT-1	2.5	5.4	97,000	59	U0.01	U0.1	0.06
MT-3	MT-5	0.5	5.3	110,000	27	U0.01	U0.1	0.34
MT-4	MT-7	0.5	5.2	74,000	7.2	0.02	U0.1	0.19
MT-5	MT-7	3.0	5.7	64,000	6	0.03	U0.1	0.04
MT-6	MT-8	2.0	5.5	74,000	12	0.02	U0.1	0.01

The results for total lead indicated that lead concentrations in the matte samples ranged from 6.4 percent to 11 percent. All of the samples had EP Toxicity results for lead above the regulatory limit of 5.0 mg/l. These values ranged from 6 mg/l to 59 mg/l. As with the battery casing EP Toxicity results, the data indicate that there is no apparent correlation between total lead concentration and EP Toxicity leachate lead concentration for these samples. Low concentrations of arsenic and cadmium were detected in the EP Toxicity leachates. These concentrations are within the regulatory limits (5.0 mg/l and 1.0 mg/l, respectively).

1.3.2.3 Surface Water

Surface water in the study area consists of two remnants of Doane Lake. The two remnants are referred to as East Doane Lake and West Doane Lake (see Figure 1.2-2).

Fill activities associated with the development of industrial facilities have dramatically altered the nature and extent of Doane

Lake. The east and west Doane Lake remnants are all that remain of the historic lake. The eastern remnant is roughly dumbbell-shaped and is located on both Gould and Schnitzer/Liquid Air properties. This remnant is bounded by Schnitzer/Liquid Air and American Steel Industries to the south, ESCO property to the northwest, and N.W. Front Street to the northeast. The western remnant is long and thin and is bounded by railroad right-of-way to the west and the properties of Rhone-Poulenc (scrap yard) and ESCO to the east.

Water depth in the east remnant varies from approximately 13 feet in the western portion to only about 4 feet in the eastern portion. Much of the bottom of the east remnant is littered with battery casings. The west remnant is fairly shallow throughout, ranging from about 5 feet to less than 3 feet. An aerator is located at the southern end of the west remnant.

Surface water samples were collected at two sites in the east Doane Lake remnant and one site in the west Doane Lake remnant. Samples were collected during August 1986 at all sites except the portion of the east remnant on the Schnitzer/Liquid Air property. These samples were collected during December 1986. All Doane Lake surface water sites were resampled during February 1987.

Direct precipitation and precipitation runoff from surrounding properties are the only sources of surface water to the lake remnants. Ground-water recharge also contributes water to the remnants. Their surface elevation rises and falls seasonally with rainfall and presumable ground-water recharge.

The east remnant receives runoff from Rhone-Poulenc, Gould, American Steel Industries, and Schnitzer/Liquid Air properties. This remnant also collects some runoff from eastern portions of the scrap yard (Rhone-Poulenc) and the ESCO property. The east remnant discharges to the north beneath N.W. Front Street; the discharge enters the Willamette River approximately 200 feet east of the railroad bridge.

The West Doane Lake remnant collects runoff from the western portions of the scrap yard and the ESCO property. There is no known surface discharge from the West Doane Lake remnant.

In early October 1986, staff gauges were installed in the Doane Lake remnants on the east and west sides of the site. Lake water levels were read weekly at the same time the water levels were measured in the wells. Lake levels of the Doane Lake remnants rose in response to pre-

precipitation beginning in late September. Lake levels fell during the dry spell in October, and then did not rise until mid-November. Approximately 4 inches of rain fell between late-October and mid-November before the levels of the east remnant rose significantly (November 24, 1986. At that time, the east remnant rose about 1.5 feet. The west remnant rose about a foot.

The east remnant continued to rise as rainfall continued until a level near that of the outlet was reached (elevation 30.5 feet). Subsequent damming of the outlet and continued precipitation caused the lake to rise to 31 feet. After reopening the outlet, the level fell to 30.7 feet.

The time lag between the start of heavy rains in late October and the initial rise of the lakes implies that either considerable bank storage capacity is present or that the lakes rise in response to both runoff and aquifer recharge. There is no simple relationship apparent between precipitation and lake level. It is thought that the east remnant rises to the level of the outlet and that rises above that are controlled by the size of the outlet.

In contrast, the west remnant rose only about 1.5 feet during the same time period. Prior to stabilizing near its present level (26.9 feet), the west remnant also rose, apparently in relation to precipitation like the east remnant. The west remnant drains a larger area than the east, and is about equal in size. It has no known outlet and is dammed at its north end. It is inferred that it is draining through the fill or an old river channel at about elevation 26 feet.

1.3.2.4 Ground Water

The site hydrostratigraphy includes unconsolidated fill and alluvial deposits overlying basalt flows. The fill consists predominately of sands and gravels, silts, and an abundance of slag, bricks, metal parts, and battery casings. The alluvial deposits consist predominantly of clays, silts, and sands with the silt content generally increasing with depth. The alluvial deposits form alternating layers of thinly bedded and interfingering lenses. The basalt flow beneath the fill and alluvial deposits is thought to be fractured and weathered. Ground water occurs in the fractured and weathered portions of the basalts.

The fill and alluvial deposits form an interconnected, heterogeneous, and anisotropic aquifer. Heterogeneity indicates that the hydraulic conductivity of the aquifer is dependent on location within the

aquifer. For instance, the hydraulic conductivity measured within a layer of the fine-grained materials would be lower than the hydraulic conductivity measured within a layer of the coarse-grained materials.

Anisotropy indicates that the hydraulic conductivity of the aquifer is dependent on the direction of measurement at any point in the aquifer. For example, the alluvial deposits beneath the site consist of layers of fine- and coarse-grained materials, each possessing a unique value of hydraulic conductivity. If the layers are horizontal, any single layer with a relatively low hydraulic conductivity causes vertical flow to be retarded, but horizontal flow can occur easily through any stratum of relatively high hydraulic conductivity (Todd, 1980).

The fill and alluvial water-bearing zones are believed to be generally unconfined; however, due to the layering, heterogeneity, and anisotropy there may be locally confined conditions within the aquifers.

Four water-bearing units are identified beneath the site. These units are the fill, the upper alluvial, the lower alluvial, and the basalt water-bearing units. The relationships of these units are presented in conceptual hydrogeologic cross-sections and flow nets shown in the RI report. As shown in the flow nets, there is a significant component of downward flow.

The hydraulic properties and material types of the water-bearing formations are highly variable; they are described more fully below.

Fill

Distribution of metals (lead, arsenic, cadmium, chromium, iron, and zinc) sulfate, pH and cation exchange capacity were evaluated by analysis of 47 subsurface samples of the fill. Samples were collected from four soil borings (B-5, B-6, B-8 and B-10) and from five monitoring well locations (W-3, W-7, W-11, W-15 and W-16). Seven of the subsurface samples were duplicates; thus a total of 40 subsurface locations within the fill were sampled and analyzed. In addition, 50 samples of the top few inches of the fill were sampled and analyzed to evaluate the surficial distribution of potential contamination. Six of the surface samples were duplicates, thus a total of 44 surface locations were sampled and analyzed.

All surface and subsurface samples of the fill were analyzed for lead and pH. Twenty-four of the subsurface samples were analyzed for arsenic and hexavalent chromium, while 28 were analyzed for cadmium,

chromium, zinc, iron, sulfate and cation exchange capacity. Eleven of the surface samples were analyzed for hexavalent chromium, while 14 were analyzed for arsenic, cadmium, chromium, zinc, iron, sulfate, and cation exchange capacity. All locations in the fill where subsurface samples were analyzed have at least one sample that shows some evidence of metal or sulfate contamination.

The fill at well W-7 has the highest concentrations of lead found in any of the soil samples taken for this study. This is to be expected because the well is in the area where battery casing fragments were buried. Indeed, the analyses of the two uppermost samples from W-7 (W-7-1 and W-7-2) are probably more representative of the casing fragments than they are of the fill (lead concentrations of 2.6 and 6.7 percent).

The pattern of lead occurrence in surface soils corresponds to areas where battery casing fragments were buried or processed. Although few samples of surface soil from the fill were evaluated for other metals, the pattern of high metal concentration is generally similar to that for lead.

There are two exceptions to this pattern. One is the chromium concentration of 170 ppm in SS-32, located in the southeastern corner of the ESCO property. This sample was taken from the clay cap emplaced over the fill on the ESCO property. This chromium concentration occurrence may have been introduced during the emplacement of the clay cap. The clay cap may have contained metal chips from the pug mill used to process the clay.

The second exception is the three samples from Liquid Air and Schnitzer property (S-15, S-17 and S-19) that have chromium concentrations from 120 to 390 ppm. These and other samples from that area (S-16 and S-18) also have high lead and zinc concentrations. The sources of these high concentrations are unknown.

In summary, variable concentrations of metals are present in much of the fill. The distribution of concentrations appears to be directly related to the known site history and to the various types of fills placed in Doane Lake. No obvious pattern of contaminant migration within the fills is apparent from the data; however, there appears to be a rough relationship between distance from the lakes or the battery fragments and lead concentration. Plots of lead concentration versus the distance of the sample from the East Doane Lake remnant or the buried battery casing fragments (whichever is closer) show that concentrations decrease at increasing distances.

Doane Lake and Willamette River Sediments

Sediment samples collected from the east remnant contained total lead concentrations ranging from 160 mg/kg (parts per million) to 12,000 mg/kg. Total lead concentration was consistently highest at station SD-02 in all sampling rounds, ranging from 3,900 mg/kg to 12,000 mg/kg. Other stations in the east remnant with relatively high total lead concentrations included SD-01 (4,100 mg/kg in round 3), SD-03 (2,600 mg/kg in round 3), and SD-11 (4,900 mg/kg in round 3). EP Toxicity tests for lead at station SD-02 showed a concentration of 28 mg/l leachable lead. No other stations in the east remnant had leachable lead concentrations greater than the EP Toxicity limit of 5 mg/l for hazardous waste designation.

Highest total arsenic concentrations were measured at SD-01 (99 mg/kg) and SD-11 (98 and 160 mg/kg). Total cadmium was highest at station SD-02 (36 mg/kg). None of these metals exceeded EP Toxicity limits.

West Doane Lake remnant sediment samples collected in 1986 and February 1987 had relatively uniform total lead concentrations at the southern end and middle portion of the remnant (1,500 and 1,000 mg/kg lead, respectively). The concentrations in samples from the northern end of the west remnant were much lower, ranging from 240 to 780 mg/kg lead. Total arsenic concentrations ranged from 20 to 76 mg/kg, total cadmium from 2.2 to 6.5 mg/kg, total chromium from 110 to 2,200 mg/kg, and total zinc from 440 to 2,000 mg/kg. EP Toxicity test results for lead, arsenic, cadmium, and chromium in west remnant sediments were all below hazardous waste limits.

Sediments collected in the Willamette River during August 1986 and February 1987 had generally low metals concentrations. Total lead concentrations ranged from 26 to 56 mg/kg. Other metals concentrations included total arsenic at 5.7 to 6.2 mg/kg, total chromium at 9 to 26 mg/kg, and total zinc at 72 to 82 mg/kg. Cadmium and hexavalent chromium concentrations were near or below the detection limits.

Alluvium

Distribution of metals (lead, arsenic, cadmium, chromium, zinc and iron), sulfate, pH, and cation exchange capacity in the alluvium were evaluated by analysis of 53 samples of the alluvium. The samples were collected from soil borings (B-5, B-6, B-8, and B-10) and from five of the monitoring well borings (W-6, W-7, W-11, W-15, and W-16). All

samples were analyzed for lead and pH. Eight of the 53 samples were selected at random for analyses for the remaining analytes. To facilitate evaluation of the potential migration of contamination of lead and other metals into the alluvium from the fill, the depth of the samples below the top of the alluvium is also shown on Table 1.3-5. Depth of the sample below ground surface, coordinates of the well/boring, and the sample designation are also shown.

Concentrations of the analytes evaluated are generally low, except for iron, which is a major constituent of the natural minerals which comprise the alluvium. Indeed, they generally are lower than the range of background concentrations that have been reported for the area, or were found in the background samples taken for this study.

The contaminant concentrations in the alluvium suggests that transport of contaminated material from the fill has not occurred. The potential transport pathways are precipitation of dissolved species, mechanical transport of contaminated sediments, and adsorption of dissolved species. This situation would be expected because of the low solubility of lead and other metals, and the low mobility of sediments.

Columbia River Basalt

No chemical analyses were performed on samples of the Columbia River Basalt, because the only samples collected were grab samples of drill cuttings. Iron and trace metal composition of the basalt are reported by Wright et al. (1979).

Ground-Water Contaminant Delineation

Results of ground-water sample analyses from the water-bearing units are presented in Tables 1.3-6 and 1.3-7. Table 1.3-6 summarizes results for metals, pH, sulfate and TOC for each of the hydrostratigraphic units discussed in this subsection. Table 1.3-7 presents average, standard deviation, minimum and maximum values for the aforementioned analytes.

Correlation coefficients between pH and the various dissolved constituents on site. Higher dissolved lead, zinc, chromium, and sulfate are all more highly correlated with low pH (a negative correlation) compared to the other constituents. This indicates that pH, sulfate and dissolved lead may be useful as primary indicators of contaminants related to activities at the Gould site. One exception to this is high sulfate encountered at well RPW-4, which is upgradient of Gould. This may indicate that sulfate contamination may not be unique

TABLE 1.3-5
SUMMARY OF CHEMICAL ANALYSES
SUBSURFACE SAMPLES OF ALLUVIUM

SAMPLE LOCATION	EAST COORD	NORTH COORD	SAMPLE DESIG.	DIST OF SAMP FB. TOP OF GEOLOGIC ALLUVIUM UNIT	SUMMARY OF LABORATORY RESULTS (1)										CATION EXCH CAP	TOTAL SOLIDS
					Pb	Pb	As	Cd	Cr	HEX Cr	Zn	Po	Se			
B-10	10109.0	9256.2	B-10-9	-9.5 ALLUVIUM	4.0	15										73.5
B-10	10109.0	9256.2	B-10-8	-4.2 ALLUVIUM	4.5	13										76.3
B-10	10109.0	9256.2	B-10-7	-2.7 ALLUVIUM	8.9	43										80.9
B-5	10652.7	9196.0	B-05-6	-3.5 ALLUVIUM	5.0	16										62.0
B-5	10652.7	9196.0	B-05-5	-1.0 ALLUVIUM	9.6	62										77.6
B-6	10538.4	9353.7	B-6-6	-0.0 ALLUVIUM	5.2	17										67.5
B-6	10538.4	9353.7	B-06-5	-1.0 ALLUVIUM	5.7	29										64.0
B-0	10009.0	9552.6	W-120-20	-47.0 ALLUVIUM	6.6	10										71.1
B-0	10009.0	9552.6	W-120-25	-37.0 ALLUVIUM	6.3	15										63.0
B-0	10009.0	9552.6	W-120-20	-27.0 ALLUVIUM	5.0	15										67.2
B-0	10009.0	9552.6	W-120-16	-17.0 ALLUVIUM	6.0	10										64.2
B-0	10009.0	9552.6	W-120-12	-7.0 ALLUVIUM	6.6	15										62.7
B-0	10116.6	9552.5	B-00-0	-1.5 ALLUVIUM	5.7	16	3.3	0.50	15	1.0	64	29000	50	26.70		60.2
W-110	9967.4	9967.5	W-110-12	-75.0 ALLUVIUM	7.0	17										71.0
W-110	9967.4	9967.5	W-110-11	-65.0 ALLUVIUM	7.2	17										73.2
W-110	9967.4	9967.5	W-110-10	-55.0 ALLUVIUM	7.2	15										71.2
W-110	9967.4	9967.5	W-110-9	-45.0 ALLUVIUM	7.4	17										75.0
W-110	9967.4	9967.5	W-110-8	-35.0 ALLUVIUM	7.9	22										70.2
W-110	9967.4	9967.5	W-110-7	-25.0 ALLUVIUM	6.5	13										72.2
W-110	9967.4	9967.5	W-110-6	-10.0 ALLUVIUM	5.0	24										56.0
W-110	9967.4	9967.5	W-110-5	-5.0 ALLUVIUM	7.0	20										57.0
W-150	10603.3	0656.6	W-150-12	-40.5 ALLUVIUM	8.0	12										73.0
W-150	10603.3	0656.6	W-150-11	-30.0 ALLUVIUM	5.6	31										74.0
W-150	10603.3	0656.6	W-150-10	-20.0 ALLUVIUM	3.6	36										79.0
W-150	10603.3	0656.6	W-150-9	-10.0 ALLUVIUM	4.3	10										82.0
W-150	10603.3	0656.6	W-150-8	-10.5 ALLUVIUM	3.6	10										79.2
W-150	10603.3	0656.6	W-150-7	-13.0 ALLUVIUM	9.4	26	4.8	0.70	39		53	22000	70	7.70		80.0
W-150	10603.3	0656.6	W-150-6	-9.0 ALLUVIUM	9.7	16										75.0
W-150	10603.3	0656.6	W-150-5	-2.0 ALLUVIUM	7.0	23	3.9	1.60	20		47	10000	64	7.50		78.2
W-150	10603.3	0656.6	W-150-3	-0.6 ALLUVIUM	10.9	17	6.0	0.60	15	0.5	47	23000	92	4.40		77.0
W-160	11001.7	0863.3	W-160-24	-49.5 ALLUVIUM	8.0	17										74.0
W-160	11001.7	0863.3	W-160-21	-39.5 ALLUVIUM	7.7	10										71.0
W-160	11001.7	0863.3	W-160-18	-49.5 ALLUVIUM	6.9	20										70.0
W-160	11001.7	0863.3	W-160-15	-39.5 ALLUVIUM	7.4	23										72.0
W-160	11001.7	0863.3	W-160-13	-29.5 ALLUVIUM	6.3	11										56.0
W-160	11001.7	0863.3	W-160-10	-20.0 ALLUVIUM	5.7	12										61.2
W-160	11001.7	0863.3	W-160-9	-14.5 ALLUVIUM	8.2	15										76.5
W-160	11001.7	0863.3	W-160-8	-9.5 ALLUVIUM	9.0	16										64.0
W-160	11001.7	0863.3	W-160-6	-5.0 ALLUVIUM	9.5	24	5.5	1.60	20		61	22000	160	12.40		70.7
W-302	10441.9	9472.4	W-30-10	-71.2 ALLUVIUM	7.9	20		0.60	23		70	31000	72	10.70		74.2
W-302	10441.9	9472.4	W-30-16	-63.0 ALLUVIUM	7.9	15										67.0
W-302	10441.9	9472.4	W-30-14	-54.0 ALLUVIUM	6.0	16										52.0
W-302	10441.9	9472.4	W-30-12	-44.0 ALLUVIUM	6.0	05										70.0
W-302	10441.9	9472.4	W-30-10	-35.5 ALLUVIUM	7.3	11										64.5
W-302	10441.9	9472.4	W-30-8	-24.0 ALLUVIUM	6.9	10		0.50	20		50	19000	54	10.60		67.0
W-302	10441.9	9472.4	W-30-6	-14.0 ALLUVIUM	5.5	16										60.0
W-302	10441.9	9472.4	W-30-5	-9.2 ALLUVIUM	6.2	16										60.0
W-302	10441.9	9472.4	W-30-4	-4.0 ALLUVIUM	5.7	22										62.0
W-65	9779.1	0731.9	W-65-4-dep	-21.5 ALLUVIUM	6.9	10										76.0
W-65	9779.1	0731.9	W-65-4	-21.5 ALLUVIUM	6.6	16		0.70	22		69	34000	13	14.40		74.0
W-65	9779.1	0731.9	W-65-3	-16.5 ALLUVIUM	7.4	20										74.0
W-65	9779.1	0731.9	W-65-2	-11.5 ALLUVIUM	7.1	20										74.0
W-65	9779.1	0731.9	W-65-1	-1.5 ALLUVIUM	5.5	29										77.0

NOTES:

1) Value for analyte on left is concentration in mg/kg (ppm).

2) Distance from top of alluvium refers to the distance above or below the fill/alluvium contact.

ALLUVIUM AVERAGE	6.9	20.9	4.7	0.9	23.0	0.0	50.6	24750.0	71.9	12.0
ALLUVIUM MAXIMUM	10.9	85.0	6.0	1.6	39.0	1.0	70.0	34000.0	160.0	26.9
ALLUVIUM STD DEV	1.6	12.6	1.0	0.4	7.4	0.3	10.6	5471.5	39.5	6.7
NUMBER OF SAMPLES	52.0	52.0	5.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0

TABLE 1.3-6

GROUND WATER - ROUND 1 (Aug - Sept, 1986), ROUND 2 (Dec, 1986 - Jan, 1987),
AND ROUND 3 (Feb, 1987) ANALYSIS RESULTS

B & M SAMPLE #	ROUND	LABO-SAMPLED	DATE	pH field	pH lab	Tot. Ph mg/L	T.R. Ph mg/L	Dis. Ph mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Zn mg/L	Dis. Fe mg/L	Dis. SO4 mg/L	TOC mg/L	Dis. Cl mg/L	Dis. NO3(N) mg/L	DT P04(P) mg/L	Dis. Co mg/L	Dis. K mg/L	Dis. Mg mg/L	Dis. Na mg/L	EC umho/cm	ALK. mg/L	HAZB. mg/L	
BASIN 1 AQUIFER																										
M-068	1	98444 - 1	09/04/86	7.2	7.6	--	--	0.02	0.005U	0.002U	0.005M	0.002U	0.44 B	52	--	310	0.05M	0.270	42.0	8.00	28.00	380	1800	500 J	230	
M-068	2	1298 - 14	12/15/86	7.3	7.3	0.01U	0.01U	0.01U	0.005U	0.002U	0.005U	0.001	0.01U	49	36.00	340	0.05M	0.100	37.0	7.50	22.00	310	1700	440	220	
M-068	3	2411 - 27	02/22/87	7.1	6.7	0.01	0.01U	0.01U	0.005U	0.002U	0.005U	0.006	0.04 B	51	9.40	270	0.05M	0.160	55.0	7.20	21.00	250	1400	430	220	
M-068 dup	1	98444 - 2	09/04/86	--	7.5	--	--	0.02	0.005M	0.007U	0.005U	0.002U	0.32 B	45	--	270	0.05M	0.260	42.0	8.20	27.00	370	1700	480 J	210	
M-110	1	98434 - 1	09/03/86	7.0	7.0	--	--	0.02	0.005U	0.002U	0.004	0.005	4.50	34	--	500	0.05M	0.062	200.0	7.40	74.00	10	1900	170 J	700	
M-110	2	1298 - 17	12/16/86	7.8	7.2	0.01	0.01U	0.01U	0.005U	0.002U	0.005M	0.004	0.20 B	32	14.00	430	0.05U	0.008	190.0	6.80	45.00	39	1800	160	750	
M-110	3	2530 - 21	02/24/87	6.0	6.5	0.01	0.01U	0.01U	0.005U	0.002U	0.005M	0.004	0.59	28	5.10	380	0.05M	0.005U	190.0	6.50	41.00	40	1700	170	820	
ALLUVIUM AQUIFER																										
PP-08	2	1298 - 57	12/30/86	6.6	6.7	0.02	0.02	0.02	0.035	0.002U	0.005M	0.019	42.00	590	80.00	1400	0.05M	0.430	390.0	1.90	110.00	390	4000	200	1400	
PP-08	3	2411 - 21	02/21/87	5.9	6.5	0.05	0.05	0.01	0.040	0.002U	0.005U	0.013	8.30	470	40.00	1300	0.05M	0.048	350.0	2.50	93.00	820	5400	580	1300	
PP-11	2	1298 - 51	12/29/86	6.3	6.3	1.00	0.02	0.01U	0.005U	0.002U	0.005M	0.024	38.00	20	40.00	190	0.05U	0.030	47.0	4.80	21.00	43	1100	160	220	
PP-11	3	2530 - 01	02/25/87	6.4	6.2	0.30	0.37	0.01	0.005U	0.002U	0.005M	0.079	8.30	17	10.00	190	0.05U	0.034	57.0	4.70	20.00	84	970	180	260	
PPM-40	1	98825 - 10	09/18/86	6.4	6.6	--	--	0.01	0.005U	0.002U	0.005M	0.006	0.30 B	1100	--	400 J	0.42	0.005U	310.0	8.20	150.00	160	5100	390	2200	
PPM-40	2	1298 - 12	12/14/86	6.5	6.4	0.01	0.01	0.01U	0.005U	0.002U	0.005M	0.013	0.01U	1500	410.00	470	0.05U	0.013	410.0	7.90	210.00	91	3900	400	2300	
PPM-40	3	2530 - 50	02/26/87	6.1	6.4	0.01U	0.01U	0.01	0.005U	0.002U	0.005M	0.270	22.00	1900	300.00	430	0.07	0.030	460.0	8.00	200.00	120	3500	370	2100	
M-010	1	98587 - 1	08/28/86	6.4	6.5	--	--	0.01U	0.005U	0.002U	0.005U	0.014	3.30	15	--	40 J	0.40	0.093	33.0	2.60	21.00	1U	440	130 J	170	
M-010	2	1298 - 2	12/10/86	6.1	6.4	0.01U	0.01U	0.01U	0.005U	0.002U	0.005M	0.015	0.01U	17	8.30	40	0.43	0.130	29.0	3.70	19.00	13	440	120	180	
M-010	3	2411 - 4	02/17/87	6.3	5.8	0.01U	0.01U	0.01U	0.005U	0.002U	0.005M	0.010	0.00 B	20	2.20	43	0.39	0.110	38.0	3.80	18.00	13	380	110	180	
M-020	1	98587 - 2	08/28/86	6.0	5.8	--	--	0.21	0.010	0.002U	0.010	6.500	570.00	14000	--	200 J	31.00	0.150	220.0	23.00	2000.00	300	12000	1UJ	4400	
M-020	2	1298 - 40	12/19/86	--	6.0	1.70	1.80	0.03	0.130	0.002U	0.016	5.000	4300.00	14000	14.00	130	14.00	0.005U	390.0	19.00	680.00	200	11000	1U	6500	
M-020	3	2530 - 42	02/25/87	5.7	4.3	0.49	0.40	0.03	0.140	0.002U	0.008	3.900	3200.00	17000	8.70	250	38.00	0.100	440.0	27.00	930.00	280	15000	60	6000	
M-020 dup	3	2530 - 43	02/26/87	--	4.2	0.50	0.49	0.05	0.280	0.002U	0.009	4.900	3900.00	18000	7.90	240	0.27	0.200	460.0	27.00	950.00	280	15000	77	6300	
M-030	1	98587 - 3	08/27/86	6.4	6.2	--	--	0.03	0.021	0.002U	0.013	0.070	420.00	3400	--	2000 J	1.60	0.570	460.0	10.00	430.00	1500	9300	160 J	3000	
M-030	2	1298 - 22	12/17/86	6.1	6.1	0.02	0.02	0.03	0.005	0.002U	0.005U	0.032	2500.00	4900	38.00	1800	0.22	0.019	780.0	14.00	420.00	430	12000	10	3400	
M-030	3	2411 - 12	02/19/87	6.2	6.0	0.02	0.02	0.02	0.018	0.002U	0.005M	0.016	720.00	3300	6.70	2100	0.15	0.021	470.0	16.00	290.00	1000	10000	78	2800	
M-030(2)	2	1298 - 19	12/21/86	7.0	6.9	0.01U	0.01U	0.01U	0.010	0.002U	0.005M	0.010	0.71 B	4	10.00	4	0.05M	0.220	39.0	5.30	12.00	22	440	200	180	
M-030(2)	3	2411 - 25	02/21/87	6.9	7.7	0.05	0.04	0.01	0.030	0.002U	0.005M	0.039	0.03 B	9	4.10	4	0.05M	0.100	47.0	5.00	10.00	28	480	210	170	
M-040	1	98587 - 4	08/27/86	6.7	6.5	--	--	0.03	0.031	0.002U	0.005U	0.160	440.00	94	--	1900 J	0.05U	0.100	480.0	12.00	290.00	180	5800	170 J	2200	
M-040	2	1298 - 4	12/11/86	6.9	6.7	0.02	0.02	0.01U	0.010	0.002U	0.005M	0.015	290.00	1U	53.00	1500	0.05M	0.014	350.0	11.00	190.00	100	5700	110	2100	
M-040	3	2411 - 22	02/21/87	6.3	6.5	0.02	0.02	0.01	0.010	0.002U	0.005M	0.007	30.00	1U	9.70	1700	0.05U	0.013	350.0	11.00	180.00	120	4900	320	2000	
M-040 dup	3	2411 - 23	02/21/87	--	6.5	0.03	0.02	0.01	0.019	0.002U	0.005M	0.005	30.00	1U	8.70	1700	0.05M	0.020	360.0	11.00	180.00	120	5000	210	2000	
M-060	1	98444 - 3	09/04/86	6.0	6.9	--	--	0.01	0.005	0.002U	0.017	0.004 B	6.70	17	--	130	0.05U	0.330	100.0	4.10	47.00	1U	1200	390 J	530	
M-060	2	1298 - 15	12/15/86	6.8	7.1	0.01U	0.01U	0.01U	0.005U	0.002U	0.005M	0.002	0.42 B	22	30.00	84	0.05M	0.022	77.0	4.00	38.00	22	800	300	390	
M-060	3	2411 - 20	02/22/87	6.5	6.6	0.04	0.01U	0.01U	0.016	0.002U	0.005M	0.011	9.70	14	13.00	42	0.05U	0.010	67.0	3.80	33.00	18	740	310	340	
M-045	1	98444 - 4	09/04/86	6.0	6.0	--	--	0.12	0.011	0.002U	0.005M	0.091	7.90	4	--	120	0.19	0.140	170.0	6.20	180.00	170	2100	630 J	700	
M-045	2	1298 - 6	12/12/86	6.4	6.9	0.02	0.02	0.01U	0.005U	0.002U	0.005M	0.010	0.01U	9	120.00	1000	0.05U	0.004	170.0	7.60	70.00	490	4300	720	700	
M-045	3	2411 - 29	02/22/87	6.2	6.5	0.05	0.04	0.02	0.021	0.002U	0.005M	0.015	4.40	31	24.00	1700	0.05M	0.037	250.0	7.60	49.00	970	5200	700	940	
M-045 dup	3	2411 - 30	02/22/87	--	6.5	0.05	0.04	0.02	0.021	0.002U	0.005M	0.015	4.40	27	19.00	1500	0.05	0.027	240.0	7.80	47.00	940	5500	760	940	
M-070	1	98825 - 1	09/15/86	3.0	3.4	--	--	0.17	0.012	0.002U	0.070	11.000	2500.00	20000	--	410 J	34.00	0.012	240.0	49.00	250.00	450	18000	1U	4200	
M-070	2	1298 - 30	12/18/86	3.7	3.9	0.16	0.15	0.12	0.017	0.005	0.200	13.000	4500.00	31000	21.00	440	12.00	0.100	220.0	50.00	1000.00	340	2100	1U	5100	
M-070	3	2530 - 47	02/24/87	3.7	3.9	0.01	0.01	0.07	0.019	0.003	0.140	8.300	1000.00 B	24000	15.00	640	0.31	0.040	470.0	45.00	940.00	480	18000	1U	5000	
M-070 dup	3	2530 - 49	02/24/87	--	3.8	0.07	0.04	0.04	0.017	0.004	0.140	7.900	1800.00	39000	9.30	470	0.32	0.042	490.0	44.00	940.00	470	19000	1U	5400	
M-080	1	98825 - 2	09/15/86	7.2	6.5	--	--	0.02	0.005U	0.002U	0.005M	0.004	34.00	41	--	2900 J	0.05M	0.020	250.0	34.00	95.00	180				

TABLE 1.3-6

PAGE 3 OF 3

**SURFACE WATER - ROUND 1 (Aug - Sept, 1986), ROUND 2 (Dec, 1986 - Jan, 1987),
AND ROUND 3 (Feb, 1987) ANALYSIS RESULTS**

ML Gould; SURFACE WATER - ROUND 1 (Aug - Sept, 1986), ROUND 2 (Dec, 1986 - Jan, 1987), AND ROUND 3 (Feb, 1987) ANALYSIS RESULTS

D & H SAMPLE #	ROUND	LAB#-SAMPLE#	DATE	pH field	pH lab	tot. Pb ug/L	I.R. Pb ug/L	Dis. Pb ug/L	Dis. As ug/L	Dis. Cd ug/L	Dis. Cr ug/L	Dis. Zn ug/L	Dis. Fe ug/L	Dis. SO4 ug/L	TIC ug/L	Dis. Cl ug/L	Dis. NH3(N) BT P04UP) ug/L	Dis. Co ug/L	Dis. K ug/L	Dis. Mg ug/L	Dis. Au ug/L	EC umho/cm	MLX ug/L	Hard. ug/L	
WEST BOWNE LAKE REMMANTS																									
SW-02	1	98374 - 3	08/19/86	7.7	--	--	--	0.05	0.021	0.002	0.005U	0.043	0.00 J	67	--	100	0.050	1.600	14.0	12.00	3.60	200	870	290 B	38
SW-02	3	2538 - 12	02/24/87	--	8.3	0.01	0.01	0.01U	0.005U	0.002U	0.005U	0.017	0.14 B	95	12.00	60	0.00	0.037	22.0	7.50	6.50	120	670	140	84
SW-02-dup	3	2538 - 13	02/24/87	--	8.5	0.02	0.02	0.01U	0.005	0.002U	0.005U	0.013	0.02 B	90	12.00	64	0.39	0.030	23.0	7.50	6.50	100	660	140	84
EAST BOWNE LAKE REMMANTS																									
SW-01	1	98470 - 1	08/20/86	6.3	6.9	--	--	0.20	0.005U	0.002U	0.005	0.030	0.10 B	390	--	84	2.10	0.008	150.0	4.80	12.00	65	1100	20	430
SW-01B	2	1298 21	12/17/86	--	7.3	0.13	0.06	0.05	--	--	--	--	--	--	4.30	--	--	--	--	--	--	--	--	--	
SW-01B	3	2538 26	02/24/87	--	7.3	0.14	0.14	0.01U	0.005U	0.002U	0.005U	0.040	0.04 B	100	3.70	39	1.10	0.005U	84.0	2.40	6.00	25	600	47	250
SW-01B dup	3	2538 26	02/24/87	--	7.2	0.15	0.15	0.01U	0.005U	0.002U	0.005U	0.035	0.01U	100	3.70	39	1.10	0.009	84.0	2.40	6.70	24	580	50	240
SW-01S	2	1298 24	12/17/86	--	7.9	0.15	0.14	0.07	--	--	--	--	--	--	2.60	--	--	--	--	--	--	--	--	--	
SW-01S	3	2538 - 25	02/24/87	--	7.4	0.13	0.12	0.01U	0.005U	0.002U	0.005U	0.020	0.15 B	100	4.10	41	1.00	0.005U	84.0	2.40	6.10	25	600	50	250
SW-01S dup	3	2538 - 27	02/24/87	--	7.4	0.13	0.13	0.01U	0.005U	0.002U	0.005U	0.041	0.05 B	100	4.30	30	2.20	0.005U	82.0	2.50	6.20	25	600	50	250
SW-01 dup	1	98470 - 2	08/20/86	6.4	7.0	--	--	0.20	0.005U	0.002U	0.005U	0.033	0.17 B	370	--	82	2.10	0.007	140.0	4.70	11.00	64	1100	30	430
SW-07B	2	1298 - 24	12/17/86	--	8.0	0.12	0.11	0.03	0.005U	0.002U	0.005U	0.015	0.01U	360	3.60	7	1.40	0.005U	100.0	2.70	6.20	36	830	34	320
SW-07B	3	2538 - 30	02/24/87	--	8.1	0.11	0.11	0.01U	0.005U	0.002U	0.005U	0.025	0.04	100	4.50	39	1.70	0.005U	92.0	2.40	6.00	25	560	50	250
SW-07S	2	1298 - 27	12/17/86	--	8.8	0.14	0.12	0.02	0.005U	0.002U	0.005U	0.024	0.01U	310	3.70	50	1.30	0.021	120.0	2.60	6.70	37	830	33	320
SW-07S	3	2538 - 29	02/24/87	--	8.1	0.11	0.11	0.01U	0.005U	0.002U	0.005U	0.021	0.01U	100	3.00	30	1.20	0.005U	85.0	2.40	5.90	25	500	50	240
SW-08B	2	1298 - 28	12/17/86	--	9.0	0.13	0.13	0.03	0.005U	0.002U	0.005U	0.011	0.01U	310	3.60	59	1.60	0.005U	120.0	3.00	6.30	37	830	32	320
SW-08S	2	1298 - 29	12/17/86	--	9.6	0.21	0.19	0.02	0.005U	0.002U	0.005U	0.012	0.01U	300	3.70	60	1.40	0.005U	110.0	2.60	6.10	36	860	33	320
WILLAMETTE RIVER																									
SW-04	1	98424 - 4	08/21/86	7.4	7.0	--	--	0.01U	0.005U	0.002U	0.005U	0.008	0.60	5	--	12	0.21	0.120	6.3	1.20	2.30	14	110	30	20
SW-04	3	2538 - 9	02/23/87	--	6.1	0.01U	0.01U	0.01U	0.005U	0.002U	0.005U	0.016	0.60 B	4	20.00	14	0.63	0.040	8.0	0.80	2.30	11	110	25	30
SW-05	1	98424 - 5	08/21/86	8.1	6.8	--	--	0.01U	0.005U	0.002U	0.005U	0.014	0.26 B	5	--	14	0.21	0.100	5.7	1.20	2.70	13	120	31	30
SW-05	3	2538 - 8	02/23/87	--	5.9	0.01U	0.01U	0.01U	0.005U	0.002U	0.005U	0.007	0.05 B	4	3.10	11	0.62	0.038	8.0	0.80	2.30	9	100	24	30
SW-05-dup	1	98424 - 6	08/21/86	8.0	6.9	--	--	0.01U	0.005U	0.002U	0.005U	0.011	0.10 B	4	--	12	0.22	0.100	6.0	1.20	2.60	13	110	30	24
SW-05-dup	3	2538 - 7	02/23/87	--	5.8	0.01U	0.01U	0.01U	0.005U	0.002U	0.005U	0.051	0.16 B	4	3.50	12	0.61	0.041	8.0	0.60	2.10	9	100	25	20

U: following a number indicates concentration below detection limit. Value shown is detection limit.

dup: following a sample number indicates sample is a duplicate.

B: following a number indicates blend concentration within 10x sample result. See Appendix B Section 4.0 for explanation.

J: following a number indicates estimated concentration. See Appendix B Section 4.0 for explanation.

TABLE 1.3-7

SHEET 1 OF 3

STATISTICAL EVALUATION OF GROUND WATER CHEMISTRY RESULTS, ROUNDS 1,2 and 3

SAMPLE	ROUND	PH	TOTAL TP	LNK TP	DIS TP	DIS AS	DIS CD	DIS CL	DIS ZN	DIS ZI	DIS SO4	TC	
SAMPLES FROM BASALT AQUIFER													
W-06B	B	1	7.6		0.02	0.005	0.002	0.005	0.002	0.44	57		
W-06B-dup	B	1	7.5		0.02	0.005	0.002	0.005	0.002	0.32	45		
W-11B	B	1	7		0.02	0.005	0.002	0.004	0.005	6.5	38		
W-06B	B	2	7.3	0.01	0.01	0.01	0.005	0.002	0.005	0.01	49	76	
W-11B	B	2	7.2	0.01	0.01	0.01	0.005	0.002	0.005	0.004	0.2	32	14
W-06B	B	3	6.7	0.01	0.01	0.01	0.005	0.002	0.005	0.006	0.06	51	9.4
W-11B	B	3	6.5	0.01	0.01	0.01	0.005	0.002	0.005	0.046	0.59	28	5.1
AVERAGE													
STD. DEV			7.1	0.010	0.010	0.014	0.005	0.002	0.005	0.010	1.16	42	16.1
nSTD. DEV			0.4	0.000	0.000	0.005	0.000	0.000	0.000	0.015	2.19	9	11.9
AVG+nSTD			6.4	0.000	0.000	0.005	0.000	0.000	0.000	0.015	2.19	9	11.9
AVG-nSTD			7.5	0.010	0.010	0.019	0.005	0.002	0.005	0.025	3.35	51	28.0
MIN			6.7	0.010	0.010	0.009	0.005	0.002	0.005	-0.005	-1.03	33	4.2
MAX			6.7	0.010	0.010	0.010	0.005	0.002	0.005	0.002	0.01	32	9.4
NOF ANALYSES			7.6	0.010	0.010	0.020	0.005	0.002	0.006	0.046	6.50	52	36.0
n (FOR n STD)			7	4	4	7	7	7	7	7	7	7	4
SAMPLES FROM LOWER PART OF ALLUVIAL AQUIFER													
RFW-4B	B	1	6.6		0.01	0.005	0.002	0.005	0.006	0.3	1100		
W-01B	B	1	6.5		0.01	0.005	0.002	0.005	0.016	3.3	15		
W-02B	B	1	5.8		0.21	0.61	0.002	0.01	6.5	570	14000		
W-06B	B	1	6.9		0.01	0.005	0.002	0.017	0.006	6.7	17		
W-07B	B	1	3.4		0.17	0.012	0.002	0.17	11	2500	20000		
W-08B	B	1	6.5		0.02	0.005	0.002	0.005	0.004	34	41		
W-11B	B	1	6.8		0.01	0.005	0.002	0.005	0.006	2.9	200		
W-15B	B	1	4.6		0.01	0.005	0.002	0.005	0.018	210	1500		
RFW-4B	B	2	6.4	0.01	0.01	0.005	0.002	0.005	0.013	0.01	1500	410	
W-01B	B	2	6.4	0.01	0.01	0.005	0.002	0.005	0.015	0.01	17	8.3	
W-02B	B	2	6	1.7	0.03	0.13	0.002	0.016	5	6300	14000	16	
W-03B(2)	B	2	6.9	0.01	0.01	0.01	0.002	0.005	0.018	0.71	6	10	
W-06B	B	2	7.1	0.01	0.01	0.006	0.002	0.005	0.002	0.62	27	30	
W-07B	B	2	3.9	0.16	0.15	0.12	0.017	0.005	0.2	13	4500	31000	21
W-08B	B	2	6.5	0.06	0.05	0.02	0.005	0.002	0.005	0.009	160	5	50
W-11B	B	2	6.5	0.02	0.03	0.01	0.005	0.002	0.005	0.003	0.01	180	27
W-12B	B	2	7.8	0.04	0.01	0.01	0.005	0.002	0.005	0.021	0.01	14	10
W-15B	B	2	6.5	0.01	0.01	0.01	0.005	0.002	0.005	0.25	67	340	72
W-16B	B	2	7.6	0.01	0.01	0.01	0.005	0.002	0.005	0.013	3.5	16	14
RFW-4B	B	3	6.4	0.01	0.01	0.01	0.005	0.002	0.005	0.27	22	1900	300
W-01B	B	3	5.8	0.01	0.01	0.01	0.005	0.002	0.005	0.01	0.08	20	2.2
W-02B	B	3	4.3	0.49	0.48	0.03	0.14	0.002	0.008	5.9	3200	17000	8.7
W-02B-dup	B	3	4.2	0.5	0.49	0.05	0.28	0.002	0.009	6.9	3900	18000	7.9
W-03B(2)	B	3	7.7	0.05	0.04	0.01	0.03	0.002	0.005	0.039	0.03	9	4.1
W-06B	B	3	6.6	0.04	0.01	0.01	0.016	0.002	0.005	0.011	9.9	14	15
W-07B	B	3	3.9	0.01	0.01	0.07	0.019	0.003	0.14	8.3	1800	26000	15
W-07B-dup	B	3	3.8	0.07	0.06	0.06	0.017	0.004	0.14	7.9	1800	39000	9.7
W-08B	B	3	6.4	0.23	0.1	0.02	0.005	0.002	0.005	0.084	50	11	52
W-11B	B	3	6.5	0.07	0.03	0.03	0.005	0.002	0.005	0.089	2.9	200	47
W-12B	B	3	6.9	0.06	0.03	0.01	0.005	0.002	0.005	0.041	0.06	11	7.4
W-12B-dup	B	3	6.8	0.01	0.01	0.01	0.005	0.002	0.005	0.041	0.06	11	8.6
W-15B	B	3	6.7	0.01	0.01	0.01	0.005	0.002	0.005	0.01	12	180	4
W-16B	B	3	6.8	0.01	0.01	0.01	0.005	0.002	0.005	0.006	0.33	4	4.1
AVERAGE													
STD. DEV			6.1	0.144	0.138	0.032	0.047	0.002	0.025	1.985	762.32	5646.4	43.350
nSTD. DEV			1.2	0.344	0.363	0.047	0.114	0.001	0.052	3.656	1550.62	10328.7	94.047
AVG+nSTD			1.2	0.344	0.363	0.047	0.114	0.001	0.052	3.656	1550.62	10328.7	94.047
AVG-nSTD			7.3	0.489	0.500	0.078	0.156	0.003	0.077	5.641	2312.94	15975.0	137.399
MIN			4.9	-0.200	-0.225	-0.015	-0.072	0.002	-0.027	-1.671	-788.31	-4682.5	-50.695
MAX			3.4	0.010	0.010	0.010	0.005	0.002	0.005	0.002	0.01	3.0	2.200
				0.700	1.000	0.200	0.100	0.005	0.000	13.000	6300.00	39000.0	410.000

TABLE 1.3-7

SHEET 2 OF 3

STATISTICAL EVALUATION OF GROUND WATER CHEMISTRY RESULTS, ROUNDS 1,2 and 3

SAMPLE	ROUND	PH-T	TOTAL FB	T-R.FB	DIS FB	DIS AS	DIS CB	DIS CR	DIS ZN	DIS FE	DIS SO4	TOC	
SAMPLES FROM UPPER AND MIDDLE PART OF ALLUVIAL AQUIFER													
M-03B	1	1	6.2		0.03	0.021	0.002	0.013	0.07	426	3406		
M-04B	1	1	6.5		0.03	0.031	0.002	0.005	0.16	460	96		
M-06S	1	1	6.8		0.12	0.011	0.002	0.005	0.091	7.9	4		
M-09B	1	1	7.1		0.04	0.05	0.002	0.005	0.022	3.4	5		
M-10B	1	1	4.4		0.02	0.005	0.002	0.005	0.005	450	126		
M-111	1	1	6.8		0.03	0.019	0.002	0.11	0.08	39	49		
M-151	1	1	2.9		0.02	0.018	0.002	0.013	0.033	6600	15000		
M-151-dup	1	1	2.9		0.02	0.005	0.002	0.01	0.031	6300	15000		
FF-08	1	2	6.7	0.02	0.02	0.035	0.002	0.005	0.019	42	590	86	
FF-11	1	2	6.3	0.02	0.01	0.005	0.002	0.005	0.024	38	70	48	
M-07B	1	2	6.1	0.02	0.02	0.03	0.005	0.002	0.005	0.032	2500	4900	30
M-04B	1	2	6.7	0.02	0.02	0.01	0.01	0.002	0.005	0.015	290	1	53
M-06S	1	2	6.9	0.02	0.02	0.01	0.005	0.002	0.005	0.014	0.01	9	126
M-09B	1	2	7	0.04	0.04	0.01	0.024	0.002	0.005	0.014	0.01	6400	120
M-10B	1	2	6.4	0.04	0.04	0.02	0.005	0.002	0.005	0.015	330	230	52
M-111	1	2	6.8	0.01	0.01	0.01	0.012	0.002	0.005	0.02	20	9	68
M-121	1	2	8.4	0.01	0.01	0.01	0.006	0.002	0.005	0.009	0.08	236	256
M-151	1	2	5.8	0.02	0.01	0.02	0.008	0.002	0.005	0.044	15000	22000	28
M-161	1	2	7.7	0.01	0.01	0.02	0.005	0.002	0.005	0.003	0.01	71	56
FF-08	1	3	6.5	0.05	0.05	0.01	0.048	0.002	0.005	0.013	8.3	470	40
FF-11	1	3	6.2	0.38	0.37	0.01	0.005	0.002	0.005	0.079	8.3	17	16
M-03B	1	3	6	0.02	0.02	0.02	0.018	0.002	0.005	0.016	720	3300	6.9
M-04B	1	3	6.5	0.02	0.02	0.01	0.018	0.002	0.005	0.007	30	1	9.7
M-04B-dup	1	3	6.5	0.03	0.02	0.01	0.019	0.002	0.005	0.005	30	1	8.7
M-06S	1	3	6.5	0.05	0.04	0.02	0.021	0.002	0.005	0.015	4.4	31	24
M-06S-dup	1	3	6.5	0.05	0.04	0.02	0.021	0.002	0.005	0.015	4.4	27	19
M-09B	1	3	6.9	0.05	0.05	0.02	0.011	0.002	0.007	0.06	2.5	106	84
M-10B	1	3	6.1	0.04	0.02	0.02	0.005	0.002	0.005	0.058	130	190	16
M-111	1	3	6.6	0.02	0.02	0.01	0.005	0.002	0.005	0.073	6.6	7	32
M-121	1	3	7.6	0.21	0.2	0.01	0.01	0.002	0.005	0.045	0.06	400	86
M-151	1	3	6	0.02	0.02	0.01	0.017	0.002	0.005	0.035	2100	8100	6
M-161	1	3	7.1	0.01	0.01	0.01	0.009	0.002	0.005	0.004	0.01	18	9.6
AVERAGE			6.4	0.09	0.05	0.02	0.0	0.002	0.009	0.035	1111	2525	52.6
STD. DEV			1.1	0.21	0.08	0.02	0.0	0.000	0.018	0.034	2962	5256	52.8
ASTD. DEV			1.1	0.21	0.08	0.02	0.0	0.000	0.018	0.034	2962	5256	52.8
AUG+ASTD			7.5	0.30	0.12	0.04	0.0	0.002	0.027	0.069	4073	7781	105.4
AUG-ASTD			5.3	0.12	-0.03	0.00	0.0	0.002	-0.009	0.002	-1851	-2731	0.2
MIN			2.9	0.01	0.01	0.01	0.0	0.002	0.005	0.003	0	1	6.9
MAX			8.4	1.00	0.37	0.12	0.1	0.002	0.110	0.160	15000	22000	250.0
NO. ANALYSES			32	24	24	32	32	32	32	32	32	32	24
n (FOR n STD)			1	1	1	1	1	1	1	1	1	1	1

TABLE 1.3-7

STATISTICAL EVALUATION OF GROUND WATER CHEMISTRY RESULTS, ROUNDS 1,2 and 3

SAMPLE	ROUND	pH-F	TOTAL FL	T.R.FL	DIS FB	DIS AS	DIS CD	DIS CR	DIS ZN	DIS FF	DIS SO4	TOC
SAMPLES FROM FILL AQUIFER												
W-075	S	1	6.7		0.02	0.009	0.002	0.005	0.002	8.9	306	
W-115	S	1	11.6		0.02	0.03	0.002	0.009	0.008	3.56	36	
W-155	S	1	12.5		0.02	0.005	0.002	0.005	0.004	2.2	9	
FF-06	S	2	7	0.82	0.11	0.03	0.002	0.005	0.037	0.01	54	36
P-01	S	2	6.9	0.01	0.01	0.006	0.002	0.005	0.019	0.02	32	5.6
P-02	S	2	6.4	0.27	0.26	0.01	0.15	0.002	0.005	0.59	240	6.3
P-03	S	2	6.8	0.01	0.01	0.005	0.002	0.005	0.009	0.01	320	6.7
P-04	S	2	10.1	0.09	0.09	0.01	0.034	0.002	0.005	0.006	100	29
W-075	S	2	6.8	1.8	0.01	0.008	0.002	0.01	0.008	5.1	310	23
W-115	S	2	11.7	0.01	0.01	0.01	0.014	0.002	0.005	0.013	30	33
W-155	S	2	12	0.01	0.01	0.01	0.005	0.002	0.005	0.033	17	8.7
W-165	S	2	12.5	0.01	0.01	0.01	0.018	0.002	0.005	0.017	14	16
FF-06	S	3	7	3.3	0.01	0.066	0.002	0.005	0.007	0.32	60	26
P-01	S	3	6.2	0.04	0.04	0.01	0.022	0.002	0.005	0.009	21	5
P-02	S	3	6	0.4	0.39	0.01	0.18	0.002	0.005	0.17	55	7
P-02-dup	S	3	5.8	0.21	0.21	0.01	0.15	0.002	0.005	0.16	48	6.8
P-03	S	3	6.9	0.01	0.01	0.005	0.002	0.005	0.02	0.01	270	7.2
P-04	S	3	9.2	0.03	0.02	0.01	0.015	0.002	0.005	0.006	80	22
W-075	S	3	6.7	4.8	0.02	0.005	0.002	0.005	0.068	2	160	27
W-075-dup	S	3	6.7	5.9	0.02	0.005	0.002	0.005	0.072	6.2	170	18
W-115	S	3	11.4	0.12	0.01	0.011	0.002	0.005	0.01	0.63	28	29
W-155	S	3	11.5	0.23	0.2	0.01	0.01	0.002	0.005	0.002	22	9.4
W-155-dup	S	3	11.5	0.27	0.26	0.01	0.01	0.002	0.005	0.01	19	8.6
W-165	S	3	12.3	3.2	0.02	0.74	0.002	0.005	0.002	0.04	130	36
AVERAGE		0.8	1.03	1.00	0.02	0.065	0.002	0.005	0.053	16	157	17.2
STD. DEV		2.5	1.71	1.67	0.02	0.149	0.000	0.001	0.121	49	178	10.8
nSTD. DEV		2.5	1.71	1.67	0.02	0.149	0.000	0.001	0.121	49	178	10.8
AVG to STD		11.4	2.73	2.68	0.04	0.214	0.002	0.007	0.174	64	335	27.6
AVG-nSTD		6.3	-0.68	-0.67	-0.00	-0.085	0.002	0.004	-0.067	-33	-21	6.1
MIN		5.8	0.01	0.01	0.01	0.005	0.002	0.005	0.002	0	9	5.6
MAX		12.5	5.90	5.80	0.11	0.740	0.002	0.010	0.590	240	720	36.0
# OF ANALYSES		24	21	21	24	24	24	24	24	24	24	21.0
n (FOR n STD)		1	1	1	1	1	1	1	1	1	1	1.0
Average all samples												
AVERAGE		6.9	0.37	0.35	0.02	0.036	0.002	0.013	0.708	636.298	2824.8	37
STD. DEV		1.9	1.03	1.01	0.03	0.103	0.000	0.033	2.335	1989.437	7141.3	65
nSTD. DEV		1.9	2.05	2.01	0.06	0.205	0.001	0.067	4.670	3978.875	14282.7	129
AVG to STD		0.8	2.42	2.36	0.09	0.242	0.003	0.080	5.378	4615.173	17107.5	102
AVG-nSTD		5.0	-1.68	-1.67	-0.04	-0.169	0.001	-0.053	-3.962	-3342.576	-11457.851	-27
MIN		3.0	0.00	0.00	0.00	0.00	0.002	0.005	0.002	0.010	1.000	2
MAX		12.5	5.90	5.80	0.21	0.740	0.005	0.200	13.000	15000.000	39000.0	410
# OF ANALYSES		96.0	74.0	74.0	96.0	96.0	96.0	96.0	96.0	96.00	96.0	74
n (FOR n STD)		1.0	NA	NA	2.0	2.0	2.0	2.0	2.0	NOT AFFI	2.0	1

to Gould's activities. The low correlation between arsenic and pH may indicate that this contaminant may not be related solely to the activities of Gould. If low pH, high dissolved lead, and/or high dissolved sulfate exists at a well, it can be expected that there are higher levels of zinc and chromium as well. This section will focus primarily on sulfate and lead levels in the ground water as an indicator of contamination related to NL/Gould activities, and the most important pollutant from a health risk standpoint. Other contaminants will be addressed in relation to lead and sulfate.

Background for sulfate and other parameters can be approximated by comparison with water samples from the wells in the basalt water-bearing unit. By this comparison, samples with sulfate greater than approximately 50 ppm are above background. In this case, wells/piezometers which show average sulfate levels greater than 50 ppm appear to represent a sulfate "plume" that may have originated from disposal of battery acid and casing fragments. This sulfate "plume" may transport lead and other soluble metals until the pH is buffered by the natural buffering capacity of the soils in the fill and alluvium. When the pH is buffered, the metals are removed from solution by precipitation.

Lead in Ground Water

Three different lead analyses were conducted on the ground-water samples from the site. Water samples were unfiltered prior to analyzing for total lead and total recoverable lead, and filtered prior to analysis of dissolved lead. Dissolved lead represents the fraction of lead in solution determined with no predigestion of the sample. Total lead and total recoverable lead represent the fraction of lead present in the sample that is obtainable after differing levels of digestion, with total lead representing a more complete digestion than total recoverable lead. Total and total recoverable lead in the waste samples represents lead that may be adsorbed or held onto colloidal or small sediment particles. Lead that is identified as total recoverable can be considered a lead that is held by colloidal particles, in addition to dissolved lead. Total lead includes all digestible lead, including some that can be considered unavailable for reaction.

In general, the ground-water samples at all wells show total and total recoverable lead to be nearly equal. This indicates that the total lead in the sample is present due to a reactive or depositional process that has removed dissolved lead from solution. The total recoverable lead may be indicative of higher dissolved lead in the past that has subsequently precipitated, adsorbed, or complexed with fine colloidal sedi-

ments in the formation, even though present dissolved lead levels are not high, or the presence of total recoverable lead may be indicative of processes that have gradually removed lead from dilute solutions. In addition, process of colloidal sediment transport of lead may have been responsible for some lead transport.

The levels of total recoverable lead measured in the ground-water samples fluctuated widely between sampling rounds. In some cases, a twenty-fold increase in total recoverable lead was measured between sampling rounds with no attendant pH, dissolved lead, or other chemical differences. This type of variation indicates that the variation is a result of sampling or well differences rather than a change in water quality. For example, if fine sediments were disturbed during the sampling process, more colloidal material might be present in the sample.

Total recoverable lead levels above 0.05 ppm have been observed in wells PP-11, W-2D, W-7D, W-8D, W-11D, W-12I, P-02, P-04, PP-06, W-7S, W-11S, W-15S, and W-16S. The presence of total recoverable lead at these locations may indicate that lead has precipitated onto sediments as a result of a wider dissolved lead plume in the past; that the soil matrix has been complexing with dissolved lead as ground water moves away from East Doane Lake in a northerly, westerly, and southerly direction (acting as a lead buffer); or that lead has migrated in some other fashion, such as on colloidal particulates. The latter mechanism would appear to be the least likely, given the general fine-grained sediments of the area. The existence of high total recoverable lead in well PP-11 may indicate that ground water has migrated preferentially along the utility line underneath NW Front Street, carrying lead and depositing it at this location.

Dissolved lead concentrations above 0.05 ppm are presently confined to ground water around wells W-7D, W-2D, and W-6S in the alluvium and PP-06 in the fill. These high dissolved lead values also generally correspond to lower pHs and elevated dissolved iron, sulfate, and chromium. Dissolved arsenic above the MCL (0.05 ppm) has been observed at wells P-2, W-16S, and PP-06, all in the fill aquifer, and at well W-2D in the alluvial aquifer. Arsenic at W-16S is not associated with high dissolved sulfate or dissolved lead.

Fill Water-Bearing Unit

Several of the wells and piezometers completed in the fill are located in or very near to the battery casing fragments (P-2, PP-6, W-7S) or the east Doane Lake remnant (P-3, P-4, W-15S). Samples of water

from three of these wells/piezometers contain sulfate in excess of 100 ppm (P-2, P-3, W-7S), as shown on Table 1.3-6. Ground water from W-16S, located next to the Liquid Air facility, also has sulfate >100 ppm.

The general outline of the sulfate "plume" is shown in Figure 1.3-4. Shown on the figure are the areas of elevated sulfate concentrations which correlate to areas of lower pH and higher metal concentrations.

The relationship of low pH and high sulfate indicates that the sulfuric acid from East Doane Lake may have migrated to the west. The lower pH, in turn, has increased the amount of lead in solution by increasing the solubility limit.

The area of higher sulfate correlates with lower pH values and elevated metal concentrations. Well PP-6 shows the only dissolved lead values above the maximum allowable for drinking water (Table 1.3-5). Wells W-16S, P-2, and PP-6 show levels of dissolved arsenic above drinking water standards. Levels of zinc are significantly elevated as compared to surrounding wells at Well P-2. Applicable Federal Standards for metals are presented in Table 1.3-8.

TABLE 1.3-8

FEDERAL STANDARDS FOR METALS

Parameter	Maximum Level (Drinking Water) (mg/l)	Maximum Level (EPA EP Toxicity Protocol) (mg/l)
Arsenic	0.05	5.0
Barium	1.0	100.0
Cadmium	0.01	1.0
Chromium	0.05	5.0
Lead	0.05	5.0
Mercury	0.002	0.2
Selenium	0.01	1.0
Silver	0.05	5.0

Upper Alluvial Water-Bearing Unit

Results of ground-water sample analyses from the upper alluvial water-bearing unit are presented in Tables 1.3-6 and 1.3-7. Table 1.3-6 summarizes results for metals, pH, sulfate and TOC for each of the

hydrostratigraphic units discussed in this subsection. Table 1.3-7 also presents average, standard deviation, minimum and maximum values for the aforementioned analytes.

None of the wells completed in the upper alluvial water-bearing unit are located below or very near to the battery casing fragments. However, W-3D, W-4D and W-15I are located immediately adjacent to the East Doane Lake remnant. Samples of water from W-3D, W-4D, and W-15I contain high sulfate concentrations. Sulfate in W-3D remained fairly constant (3,400 ppm, 4,900 ppm, and 3,300 ppm during rounds 1, 2, and 3, respectively). W-15I increased from 15,000 ppm during round 1 to 22,000 ppm during round 2, and then decreased to 8,800 ppm during round 3. However, water from W-4D, located between W-3D and W-15I has lower sulfate concentrations. Sulfate concentrations in W-4D declined from a high of 96 ppm during round 1 to 1 ppm during rounds 2 and 3 (Table 1.3-6).

Wells W-10D and W-12I, and piezometer PP-8 also have sulfate values which appear to be elevated above background. In this case, the elevated sulfate concentrations in wells W-3D, W-10D, W-12I, W-15I and PP-8 also appear to represent a sulfate "plume" that may have originated from disposal of battery acid and casing fragments. As discussed previously, this sulfate "plume" may transport lead and other soluble metals until the pH is buffered or lead is complexed by the natural buffering capacity of the soils in the fill and alluvium. However, only well W-6S shows lead above 0.05 ppm, and only during Round 1 (Table 1.3-6). Since the theoretical solubility of lead at the pH encountered in this area is greater than 0.05 ppm, it appears that soluble lead migration may indeed be inhibited by soil ion exchange as the sulfate "plume" migrates away from the source. This indication of inhibition supports a theory that past releases of acidic water from the site were not large enough to exhaust the exchange capacity of the soil.

A similar trend is observed in this water-bearing unit as compared with the fill. Both show elevated dissolved metals, including zinc, arsenic, iron and chromium, and sulfate levels in association with lower pH values. As has been previously indicated, high sulfate is not necessarily associated with high dissolved metals and low pH, however, the association of elevated levels of dissolved metals and sulfate with low pH is stronger in the alluvium as a whole as compared with the fill. This indicates that the distribution of these contaminants has been less dispersed or diluted by ground-water movement.

The sulfate "plume" with associated low pH has migrated west as shown in Figure 1.3-5. Increased dissolved metal concentrations appear

to be the result of the lower pH which increases the solubility of metals, thus carrying high levels of these species as the "plume" migrates. Figure 1.3-5 shows the general region of high sulfate, high dissolved metals and low pH for the upper alluvium. Well W-11I also shows chromium levels above drinking water standards on one sampling date, however, other samples show levels below detection limit.

Lower Alluvial Water-Bearing Unit

Results of ground-water sample analyses from the lower alluvial water-bearing unit are presented in Tables 1.3-6 and 1.3-7. Table 1.3-6 summarizes results for metals, pH, sulfate and TOC for each of the hydrostratigraphic units discussed in this subsection. Table 1.3-7 presents average, standard deviation, minimum and maximum values for the aforementioned analytes.

Two of the wells completed in the lower alluvial water-bearing unit are located below or very near to the battery casing fragments (W-2D, and W-7D). In addition, W-15D is located immediately adjacent to the East Doane Lake remnant. Samples of water from W-2D contain high sulfate concentration. Sulfate in W-2D remained fairly constant (14,000 ppm during rounds 1 and 2, and 17,000 ppm during round 3). Sulfate concentrations from W-15D decreased from 1,500 ppm during round 1 to 340 ppm during round 2 to 180 ppm during round 3.

Well W-11D also has sulfate values which appear to be elevated above background, at a relatively constant concentration of 180 ppm to 200 ppm. The elevated sulfate in wells W-2D, W-7D, W-11D, and W-15D also appears to indicate a sulfate "plume" that may have originated from disposal of battery acid and casing fragments. This sulfate "plume" may transport lead and other soluble metals. However, only wells W-2D and W-7D have shown lead concentrations above 0.05 ppm (Table 1.3-5). Thus, it appears that elevated concentrations of lead currently reach the lower alluvial water-bearing zone only in the area immediately below the battery casing fragments. This finding lends additional support to the hypothesis that no substantial releases of lead above 0.05 ppm has taken place.

Well RPW-4 also has an apparently elevated sulfate concentration. Because it is "upgradient" of the other wells with high sulfate, it could be argued that sulfate from off site is a contributing factor to onsite contaminant migration. However, the two wells immediately down-gradient from RPW-4 (W-1D and W-6D) have low sulfate values.

Figure 1.3-6 shows the estimated contaminant "plume" as it exists in the lower alluvium. Wells W-2D and W-7D are the only wells that show dissolved lead above drinking water standards.

Basalt Water-Bearing Unit

Results of ground-water sample analyses from the basalt water-bearing unit are presented in Tables 1.3-6 and 1.3-7. Table 1.3-6 summarizes results for metals, pH, sulfate and TOC for each of the hydrostratigraphic units discussed in this subsection. Table 1.3-7 presents average, standard deviation, minimum and maximum values for the aforementioned analytes.

Analyses of water from the basalt indicate that sulfate, pH, and metals are generally within the ranges reported for the basalt aquifer in the area (Hart and Newcomb, 1965). The one apparent exception to this situation appears to be a reported concentration of 0.046 ppm zinc in Well W-11B during round 3. Dissolved lead concentrations in the basalt aquifer are less than 0.01 ppm.

Summary

The potential for dissolved lead values to occur at concentrations above the drinking water standard of 0.05 ppm exists in the fill, upper alluvial and lower alluvial water-bearing units in the region below the Gould site where battery casings and sulfuric acid have been deposited. In general, values above 0.05 ppm are also associated with other elevated dissolved metals, primarily zinc and arsenic, chromium and iron, elevated sulfate and lower pH. Low pH and sulfate concentrations greater than 50 ppm serve as indicators of potentially elevated dissolved metal concentrations, including lead. The identified extent of the sulfate "plume" indicates that it has migrated as far as well W-10D in the upper alluvium. The maximum dissolved lead concentrations diminish moving away from East Doane Lake and wells W-2 and W-7, indicating that dissolved lead migration is being retarded. Dissolved lead values above drinking water standards exist only in wells W-7D and W-2D in the lower alluvium, and in well PP-6 in the fill. These locations are directly beneath the battery casing piles. Wells W-2D and W-7D also show pH values below 6.0. The distribution of total recoverable lead may indicate that dissolved lead is, or at one time in the past was, accumulating in the soils.

The sulfate and lead migration distribution patterns indicate a source near the battery casing piles and East Doane Lake with a subsequent migration downgradient towards West Doane Lake and to the northeast, with the maximum migration occurring in the upper alluvium. The distribution patterns indicate considerable exchange capacity in the soil, thus leading to confidence in the hypothesis that no large-scale releases of dissolved lead in ground water occurred in the past. However, some lead may have been transported along the utility lines as far as well PP-11, indicated by the presence of total recoverable lead at this well.

1.3.2.5 Contaminant Transport

The primary source materials contribute lead, zinc, possibly arsenic, chromium, and other materials to the ground water. Available data suggest that lead, zinc, arsenic and chromium are the contaminants of concern that have migrated in ground water. The mobility of lead, arsenic, and zinc are similar under conditions found at the site, although zinc may persist in ground water more than lead. Chromium mobility is enhanced by the increased solubility of the hexavalent species.

Two types of lead sources exist at the Gould site. The major source includes debris remaining from earlier lead recovery operations, including battery casings and parts and the smelter matte. Another source which may be significant is the lead incorporated in the subsurface near the industrial sources. This lead, sorbed on soil mineral phases or precipitated as oxides, hydroxides, or sulfate, may act as a source for lead in ground water after the primary (industrial) sources have been removed or stabilized. These secondary sources may arise in two ways; the sorption of dissolved lead onto clays and iron oxides in the soil, and as a chemical precipitate that forms where significant changes in ground-water chemistry are encountered.

The most important chemical change encountered in the ground-water system on (and near) the site is pH change. At the primary sources, the pH is generally quite low (pH <5) because of the sulfuric acid from the scrapped batteries. The pH gradually increases away from the sources because of the buffering effect of reactions with natural soil minerals. The by-product debris from the air products operation nearby is a source of very high pH water. As pH increases, the solubility of lead in water decreases, accompanied by the precipitation of lead oxides and hydroxides. At very high pH (pH >11), lead increases in solubility as stable hydroxy-complexes form (Schock and Gardels 1983). High pH values exist at the Liquid Air site as a result of alkaline wastes; however, associated elevated dissolved lead is not present.

Lead Solubility On Site

The amount of lead that can be dissolved in ground water is a function of temperature, pH, other dissolved species present, amount of available lead and contact time. Assuming temperatures to be constant, all these factors are significant with regard to lead solubility in ground water in the study area.

Theoretical maximum levels of dissolved lead, in thermodynamic equilibrium with an unlimiting source, can be estimated from studies done by the EPA (Davies and Everhard 1973) on lead equilibrium in "hard" water. These estimates are a function of pH only, as time and lead were not limiting, and other interference such as cation exchange and adsorption were not present in the study.

Typically, the dissolved lead concentration observed in the ground water on site were much less than the theoretical maximums. The relationship of pH to the ratio of observed dissolved lead (for samples with dissolved lead above detection limits) to theoretical maximum dissolved lead shows a general trend that indicates a low observed solubility ratio when theoretical solubility is high (at high and low pHs), and a high ratio (tending towards 1.0) when the theoretical solubility is low (around neutral pHs).

The solubility relationship may be a function of limited lead available for dissolution. This contention is supported by the observation that if the water samples from wells W-2D and W-7D, which exhibit low pHs in an environment of more readily available lead (beneath the battery casing piles) are treated separately, the general relationship already described becomes clearer and a distinct solubility relationship exists where lead is more available (i.e., as pH decreases, lead solubility increases).

The reasons for the observed condition are probably complex. At high pHs, observed in the vicinity of wells W-15 and W-16, the impact of alkaline material from Schnitzer Liquid/Air, although increasing pH and subsequent solubility potential, may also provide an environment of increased exchange capacity and subsequent decrease in dissolved lead. Lead may also exist in more or less soluble forms (depending on pH and other dissolved species) with respect to location, waste type and chemical environment. High TOC may also provide a matrix that can remove dissolved lead.

The subsurface chemistry and physical conditions are sufficiently varied on site to create a situation where lead solubility potential can

also be highly variable. However, given the observed solubilities, pH appears to be a fairly good indicator of the potential fraction of theoretical values that may become dissolved, especially if the conditions at wells W-7D and W-2D are regarded as a separate case.

At approximately pH 6.0, the condition at wells W-7D and W-2D becomes similar to the general site condition with respect to lead solubility. Since acids are no longer being dumped into East Doane Lake, it is expected that pHs will increase from inflow of more neutral ground water at W-7D and W-2D until pH levels at that site are similar to pH levels recorded upgradient or in the fill. Therefore, it is assumed that present conditions represent the worst case with respect to future possible dissolved lead transport.

Particulate Transport

In addition to transport of lead and other contaminants in a dissolved state, it is possible that these can be transported in an adsorbed or complexed state, along with transport of fine colloidal sediments in ground water. Chemicals strongly adsorbed to colloidal surface may move with the carrier material to deeper layers of the unsaturated zone during subsurface flow events or laterally in the course of horizontal ground-water flow. The characteristics of the subsurface flow and the characteristics of the porous media both influence the potential for such movement. If the porosity of the media is such that a sufficient number of pores are larger than the particle being transported, the pores are sufficiently interconnected and flow velocities are high enough, colloidal soil particles can be transported significant distances.

Results of previous studies concerned with this transport mechanism by Vinten et al. (1983) has shown that in coarse sands, up to 50 percent of some contaminants have been transported a distance of 5 cm or more by particulate transport. In sandy loams, they found up to 2 percent transport greater than 5 cm and in silt loams, less than 5 percent of the contaminants studied were transported greater than 5 cm via particulate transport.

The result of the above study indicates that particulate transport of sorbed contaminants may be an important mechanism for short distance contaminant transport in soils with permeabilities greater than those found in sands and coarse sands. The soils in the study area exhibit generally low permeabilities except in isolated, non-continuous pockets in the fill that exhibit permeabilities on the order of a coarse sand.

Particulate transport of lead or other contaminants on site may be important over short distances in localized areas; however, it is not considered as an important potential pathway of contaminant transport mechanism for the Gould site.

Retardation

The factors that can cause lead and other contaminants to move more slowly than ground water include precipitation and sorption. The pH of ground water is the primary variable that affects the solubility of metals, although oxidation potential, salinity and presence of various anions and complexing agents may be significant. The specific solid lead compounds that determine the stability are determined by ground-water conditions. Oxides, hydroxides, sulfates, and mixed species are expected to be important at various areas in the subsurface of the site. Lead solubilities are expected to be 150 to 200 ppb at maximum in areas of very low or very high pH and 10 to 20 ppb or less in areas of neutral to slightly elevated pH.

These solubilities are theoretical, and generally represent upper limits for dissolved lead. Kinetic effects and sorption will tend to decrease the lead in solution with respect to the solubility limits. The laboratory leach tests should provide data on the actual concentrations expected.

Contaminant Transport Velocity

The average linear velocity of a contaminant plume within the fill water-bearing unit is defined here by the following relationship:

$$V_c = D / (t_s - t_c)$$

where:

V_c	= average linear plume velocity	(length/time)
D	= distance from source to the observation point	(length)
t_s	= time contaminant source began	(time)
t_c	= time of arrival at the observation point of $C/Co = 0.5$	(time)
C	= concentration observed	(mg/l)
Co	= steady state concentration	(mg/l)

The range of plume velocities are estimated from the sulfate (SO_4) concentrations in the ground water at wells W-7S and W-11S. Both wells appeared to have reached steady state concentrations of 300 to 310 and 30 to 36 milligrams per liter (mg/l) respectively, as measured during this investigation. Sulfate is selected because it is the most mobile

of the contaminants investigated. Plume velocities for other less mobile contaminants would be lower.

Sensitivity calculations were performed to assess the uncertainty of the input parameters. The uncertainties are:

1. Exact time of arrival of the $C/Co = 0.5$ concentration at the observation point; and
2. Travel time within the vadose zone.

The time of arrival of the $C/Co = 0.5$ concentration is sometime between 1949 when disposal of battery wastes began and 1981 when disposal of waste was suspended. Within this 32-year period, the sulfate from the source arrived at wells W-7S and W-11S. Thus, for the purpose of estimating the approximate order of magnitude of the contaminant transport velocity, an arrival time range of 1 to 30 years is assumed.

Based on this assumption and the distance between wells W-7S and W-11S, the estimated range of plume velocity for sulfate is 0.07 to 2.2 feet per day. This estimate is assumed to be worst-case in that retardation mechanisms of the contaminants are ignored.

Concentrations of Airborne Lead

Airborne lead concentrations measured as part of the RI/FS study conducted by Dames & Moore are shown in Table 1.3-9 and Appendix E. The highest daily values observed during the sampling period were 5.20 ug/m^3 at sampler S-3 on August 25, 1986, and 12.76 ug/m^3 at sampler S-3 on June 24, 1987. These coincided with observed site activity. Specifically, on August 25, 1986, workers from a firm acquiring the inoperative battery casing separating machine were steam cleaning and decontaminating the equipment on the Gould property prior to moving the equipment from the site. On that day, Dames & Moore personnel observed clouds of airborne particulate from the cleaning operations move over the operating sampler S-3. This would account for the high concentrations of airborne lead recorded on that date. The cleaning operations took place near the battery casing piles, northwest of sampler S-3 (along a prevailing wind direction) approximately 100 yards away from the sampler. On June 24, 1987, battery casings were being excavated for an engineering study.

The highest monthly average airborne lead concentrations observed (as shown in Table 1.3-10) were 1.56 ug/m^3 and 0.94 ug/m^3 , observed again at sampler S-3 June 1987 and in August 1986. The June 1987 monthly

average is just above the federal and state ambient air standard for lead of 1.5 ug/m³ on a quarterly basis; the average is highly skewed by the one high reading on June 24, 1987. The average readings from other samplers during August 1986 were similarly higher than averages during other months, confirming the expected trend of higher airborne particulate levels during the dry summer months. Dry weather, along with the remedial activities and equipment cleaning (i.e., more dust-generating activities occurring around the site), may account for the significantly higher values observed during this time period.

TABLE 1.3-9

AIRBORNE LEAD CONCENTRATIONS
DAILY AVERAGES

Sheet 1 of 3

Daily Averages (ug/m ³)					
Date	S-1 Sampler	S-1A Sampler	S-2 Sampler	S-3 Sampler	Site Activity*
04-16-86	0.09	0.06 ^a	0.04	void ^b	
04-20-86	0.10	0.19	0.14	0.15	
04-26-86	0.10	0.04	0.09	0.09	
05-02-86	0.05	0.04	0.09	0.10	
05-08-86	0.10	0.09	0.09	0.09	
05-14-86	0.05	0.05	0.05	0.05	
05-20-86	0.10	0.09	0.09	0.10	
05-26-86	0.10	0.09	0.10 ^a	0.15	
05-29-86	0.34	0.33	0.14	1.10 ^a	
06-01-86	0.19	0.17	0.10	0.42	
06-02-86	0.05	0.13 ^a	0.17 ^a	0.34 ^a	4
06-03-86	0.10	0.08	0.10	0.11 ^a	4
06-04-86	0.05	0.04	0.15	0.17	4
06-05-86	0.10	0.04	0.11 ^a	0.05	4
06-07-86	0.14	0.12	0.14	1.25	4
06-10-86	0.44	--	0.62	0.30	4
06-11-86	0.20	--	0.20	0.21	4
06-13-86	0.09	0.08	0.21	0.22	
06-19-86	0.05	0.04	0.05	0.10	
06-25-86	0.19	0.16	0.23	0.09	
07-01-86	0.10	0.12	0.15	0.15	
07-07-86	0.05	0.08	0.09	0.05	4
07-13-86	0.05	0.08	0.13	0.15	1
07-15-86	0.05	--	0.23	0.24	4
07-16-86	0.04	--	0.08	0.09	4
07-17-86	0.09	--	0.09	0.14	4
07-18-86	0.09	--	0.09	0.09	4
07-19-86	0.09	0.14	0.22	0.23	
07-22-86	0.27	--	0.75	0.22	1
07-23-86	0.39	--	0.26	0.15 ^a	1
07-24-86	0.45	--	0.44	0.05 ^a	1
07-25-86	0.81	0.67	0.84	0.21	1
07-28-86	0.33	--	0.39	0.33	1
07-29-86	0.61	--	0.88	0.37	1
07-30-86	0.61	--	0.86	0.81	1
07-31-86	0.53	0.51	0.61	0.44	1
08-01-86	1.48 ^c	--	1.38 ^c	1.11 ^c	1
08-04-86	0.63	--	0.67	0.88	1
08-05-86	1.04	--	1.40	0.54	1
08-06-86	0.84	0.94	0.74	0.58	1
08-07-86	0.80	--	0.63	0.43	1,3,6

TABLE 1.3-9 (Continued)

Sheet 2 of 3

Daily Averages (ug/m ³)					
Date	S-1 Sampler	S-1A Sampler	S-2 Sampler	S-3 Sampler	Site Activity*
08-08-86	0.71	--	0.40	0.70	1
08-11-86	0.27	--	0.17	1.12	1
08-12-86	0.26	0.24	0.18	0.42	1
08-13-86	0.32	--	0.26	0.37	1,3
08-14-86	0.65	--	0.96	1.17	1
08-15-86	0.55	--	0.43	0.13	1
08-18-86	0.48	0.57	0.39	0.53	3
08-22-86	0.46	--	0.52	1.59	3,5
08-24-86	0.15	0.14	0.21	0.60	3
08-25-86	0.94	--	1.37	5.20	3,7
08-26-86	0.53	--	0.48	1.42	3
08-27-86	0.60	--	0.91	1.48	3
08-30-86	0.04	0.08	0.04	0.08	3
09-02-86	0.42	--	0.17	0.24	2,3
09-03-86	0.41	--	0.35	0.60	2,3
09-05-86	0.33	0.27	0.49	0.44	3,6,7
09-11-86	0.27	0.27	0.34	1.16	3,6,7
09-12-86	0.23	--	2.03	1.56	3
09-17-86	0.05	0.04	0.09	0.21	3
09-23-86	0.09	0.08	0.09	0.12	6,7
09-24-86	void ^d	--	0.25	0.08	7
09-29-86	0.21	0.20	0.09	0.17	3
10-05-86	0.08	0.08	0.09	0.07	
10-11-86	0.20	0.15	1.07	0.07	
10-17-86	0.17	0.15	0.17	0.15	
10-23-86	0.24	0.23	0.26	0.29	6
10-29-86	0.08	0.08	0.13	0.07	
11-04-86	0.20	0.19	0.21	0.32	
11-10-86	0.16	0.15	0.14	0.15	
11-16-86	0.04	0.04	void ^d	0.04	
11-22-86	0.04	0.04	0.04	0.03	
11-25-86	0.12	--	0.08	0.11	1
11-28-86	0.08	0.04	0.04	0.07	1
12-01-86	0.12	--	0.12	0.10	1,6
12-02-86	0.12	--	0.12	0.07	1
12-03-86	0.12	--	0.16	0.10	1
12-04-86	0.12	0.11	0.16	0.11	1,3
12-05-86	0.15	--	0.16	0.14	1
12-08-86	0.08	--	0.08	0.07	1,6
12-09-86	0.11	--	0.12	0.07	1,6
12-10-86	0.15	0.14	0.12	0.08 ^a	1,3
12-11-86	0.19	--	0.24	0.17	1,3

TABLE 1.3-9 (Concluded)

Sheet 3 of 3

Date	Daily Averages (ug/m ³)					Site Activity*
	S-1 Sampler	S-1A Sampler	S-2 Sampler	S-3 Sampler		
12-12-86	0.12	--	0.12	0.10		1,3
12-15-86	0.20	--	0.16	0.17		1,3
12-16-86	0.25	0.23	0.24	0.20		1,3,6
12-17-86	0.35	--	0.52	0.31		1,3,5
12-18-86	0.11	--	0.24	0.14		1,3
12-19-86	0.08	--	0.08	0.08		1,3
12-22-86	0.08	0.08	0.12	0.07		3
12-23-86	0.04	--	0.08	void ^d		3
12-28-86	0.04	0.04	0.08	0.03		3
1-5-87	0.16	--	0.12	0.1		1,4
1-6-87	0.12	--	0.12	0.1		1,4
1-7-87	0.39 ^a	--	0.12	0.1		1,2

*Site Activity Code

- 1 - Soil bearing/well installation
- 2 - Test pits/battery casing and matte sampling
- 3 - Well development/ground-water sampling
- 4 - Surface soil sampling
- 5 - Surface water/sediment sampling
- 6 - Water level measurements
- 7 - Other activities

^a Void by EPA standards--Sampler run time was less than 23 hours, but at least 12 hours.

^b Dixon chart was questionable.

^c Conditions included drilling on Rhone Poulenc and ESCO, plus strong winds.

^d Sampler run time was less than 12 hours.

TABLE 1.3-10

AIRBORNE LEAD CONCENTRATIONS
MONTHLY AND QUARTERLY AVERAGES

Date	Averages (ug/m ³)			
	Sampler S-1	Sampler S-1A	Sampler S-2	Sampler S-3
<u>Monthly Arithmetic Averages</u>				
April, 1986 ^a	0.10	0.10	0.09	0.08
May	0.08	0.07	0.08	0.10
June	0.16	0.12	0.19	0.36
July	0.25	0.27	0.33	0.28
August	0.51	0.39	0.54	0.94
September	0.19	0.17	0.37	0.45
October	0.15	0.14	0.34	0.13
November	0.13	0.09	0.10	0.14
December	0.12	0.12	0.15	0.10
June	0.37	--	0.15	1.56
September	0.09	--	0.08	0.02
<u>Quarterly Arithmetic Averages</u>				
April to June	0.11	0.10	0.12	0.18
July to September	0.32	0.28	0.41	0.56
October to December	0.13	0.12	0.20	0.12

^a April averages include only 3 of the 5 EPA National Schedule weeks.

The highest quarterly average airborne lead concentration of 0.55 ug/m³ (as shown in Table 1.3-9) was observed at sampler S-3 during the July to September 1986 quarter. This concentration is just over one third of the allowable federal and state ambient air quality standards of 1.5 ug/m³ as a arithmetic quarterly average. This quarter was similarly high for all monitors, again confirming the trend for higher airborne particulate levels during the dry summer months. The second highest quarterly average, 0.41 ug/m³, was observed at sampler S-2. Both samplers S-2 and S-3 are the closest to the battery casing piles and could be expected to show the highest lead levels, if the casing piles are the main source of airborne lead.

1.3.3 Risks to Human Health and the Environment

An endangerment assessment (Appendix A.) was performed to evaluate the potential for human health and environmental exposure risks associated with the no-action alternative as well as the remedial action alternatives. The primary contaminant included in the assessment is lead, which is not considered to be a carcinogen, along with arsenic and cadmium. While arsenic is treated as a carcinogen for both inhalation and ingestion routes, cadmium is treated as a carcinogen for only the inhalation route. The endangerment assessment includes a summary of the toxicological properties of the chemicals. Both lead and arsenic are found in the site's airborne dust, soil, and surface and ground water, and cadmium is found in airborne dust and soil.

Three potential critical pathways were identified, including airborne exposure from on-site fugitive dust sources, incidental oral ingestion of contaminants, and dermal contact as well as incidental ingestion of lead from surface water in the East Doane Lake remnant. No exposure from drinking water was identified, because city water serves the area and wells to obtain drinking water are drilled into the deep basalt aquifer which has not been contaminated.

Under the no-action alternative, scenarios were developed for on-site worker and just off-site (at the fenceline) residential exposure to airborne dust assumed conservatively to contain particular levels of contaminants. Air contaminant levels were modeled using the Industrial Source Complex Short Term (ISCST) model. Worker and residential scenarios were also developed for incidental oral ingestion on-site of contaminants using best and upper bound estimates of contamination levels as well as low and high doses of ingested soil.

The no-action scenario for surface water exposure assumed that children might gain access to East Doane Lake for swimming. The

endangerment assessment also examined the environmental effects on the Willamette River of discharging surface and ground water containing lead.

Best and upper bound estimates of contaminant levels were used to calculate average daily exposures for worker and residential populations. Where available, applicable or relevant and appropriate requirements (ARARs) were used in evaluating the health risk associated with observed and estimated exposure concentrations. For noncarcinogenic effects, exposure levels for lead and cadmium were compared with acceptable chronic intakes provided in EPA's Superfund Public Health Evaluation Manual (SPHEM 1986). For carcinogenic effects, unit risk estimates were developed using the carcinogenic potency factors from the SPHEM.

1.4 OBJECTIVES OF REMEDIAL ACTION

The objectives of remediation for the Gould site are to provide adequate protection of human health and the environment from the effects of contaminants introduced by past practices at the Gould site. The objectives do not include the reduction or control of risk associated with off-site generated contaminants. Specific objectives for any remediation at the Gould site follow:

1. To protect human health from effects of contaminants in public drinking water supplies.
2. To protect human health and the environment from detrimental effects of airborne metals contamination.
3. To protect human health and the environment from detrimental effects of contact with contaminated surface water or soils.
4. To protect the water quality of the Willamette River from degradation because of site contaminants.

2.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

Methods available to remedy an uncontrolled hazardous waste site apply source control techniques, receptor control techniques, or techniques for the management of contaminant migration; or they apply some combination of these three techniques. Source control techniques reduce the hazard of a site by lessening the source of risk at the site. Receptor control techniques reduce the hazard of a site by limiting access to the site and its dangers. Management of contaminant migration reduces the hazard of a site by restricting the avenues by which hazardous materials can move from the site into the surroundings.

At a specific hazardous waste site, many of the available remediation methods will not be appropriate. Certain methods, for example, will not achieve remedial objectives due to the chemical properties of site contaminants, contaminant location, or the physical surroundings. It is possible, therefore, to eliminate some methods from consideration on technical grounds. Those methods that may not achieve remedial objectives within a reasonable time, may prove difficult to implement, or rely on unproven technologies may be eliminated.

This section summarizes the process used to determine appropriate remediation technologies for the Gould site. The selection and screening of available technologies is a four-step process. First, the criteria for screening are developed from the remedial objectives, the characteristics of the contaminants and the site conditions. Then, general response actions that diminish site problems and meet clean-up goals and objectives are identified. Next, technologies available for performing each response action are investigated. Finally, infeasible or inapplicable technologies are eliminated from further consideration.

The remaining technologies are subsequently combined into preliminary remedial action alternatives. The preliminary alternatives are screened for implementability, effectiveness and cost. The screening process produces a small group of final remedial action alternatives.

The process of combining technologies and screening the resulting alternatives is described in Section 3.0.

EXECUTIVE SUMMARY

This report presents the results of the Feasibility Study for the Gould Inc. site (hereafter called Gould site) in Portland, Oregon. The study was performed for NL Industries, Inc. and Gould Inc. as required by Administrative Order on Consent, EPA Docket Number 1085-05-08-106, dated August 29, 1985. The Feasibility Study follows submittal of a Draft Remedial Investigation report in June, 1987 and a Final Remedial Investigation report in November, 1987.

As required by the Work Plan developed pursuant to the Consent Order, the purpose of the Feasibility Study is to develop and evaluate a range of remedial action alternatives for the Gould site based on the extent of contamination found on the site during the RI. The alternatives are screened and evaluated, then compared. As a result of this process, one alternative is recommended for implementation.

The Feasibility Study process began with the identification of preliminary remedial technologies applicable to the site. In order to properly identify applicable technologies, remedial objectives for the site were developed. Those remedial objectives are:

1. To protect human health from the effects of contaminants in public drinking water supplies.
2. To protect human health and the environment from detrimental effects of airborne metals contamination.
3. To protect human health and the environment from detrimental effects of contact with contaminated surface water or soils.
4. To protect the water quality of the Willamette River from degradation because of site contaminants.

Given those remedial objectives, and mindful of the constraints of the site, criteria were developed for screening of technologies based on the stated objectives and on the guidance and policies of regulatory agencies. Preliminary technologies were screened to those which satisfied the SARA requirements for use of treatment technologies, as well as those which would allow subsequently developed alternatives to comply with site ARARs.

The screened preliminary remedial technologies were then combined into a total of 30 preliminary remedial alternatives. Treatment alternatives were developed including alternatives which required no long-

term management of residuals, alternatives which include treatment as a principal element, containment alternatives, and a No-Action Alternative. The preliminary remedial alternatives were screened considering the factors of effectiveness, implementability, and cost. As required by EPA guidance revised under SARA, cost was considered only as a factor to discriminate between alternatives which would provide similar results. The purpose of the initial screen was to identify a small number of alternatives for further detailed analysis, and to preserve a range of treatment alternatives.

Section 3 of the report describes the preliminary screening process. In order to effectively screen the remedial alternatives, options which addressed the site fill materials were evaluated first, without consideration for surface treatment, surface water treatment or ground-water treatment. This approach to the development of alternatives was necessary because the wide range of materials and pathways present at the site would result in an unworkable matrix of conditions if all were considered simultaneously. Surface treatment, surface water treatment and ground-water treatment address several of the identified remedial objectives and are important components of the general response action categories. Consideration of technologies for addressing these components is included in the FS, but evaluation of these technologies is, in most cases, somewhat separate from evaluation of the fully-developed alternative.

The preliminary screening resulted in a total of seven alternatives identified for detailed evaluation as Final Candidate Alternatives. The seven Final Candidate Alternatives, identified briefly, are:

- ° Alternative 1 - No-Action Alternative.
- ° Alternative 2A - Removal and Disposal of Surface Piles of Battery Casings; Lime Application to Contaminated Soils.
- ° Alternative 2B - Removal and Disposal of Surface Piles of Battery Casings; Capping of Contaminated Surface Soils; Regrading of the Site and Isolation of East Doane Lake.
- ° Alternative 8 - Removal and Disposal of Surface Piles of Battery Casings and Sediments of East Doane Lake; Capping of Contaminated Surface Soils; Regrading of the Site and Isolation of East Doane Lake.

- ° Alternative 10 - Excavation and Separation of Battery Casing Components, and Subsequent Off-Site Management of Casings; Fixation or Stabilization of Surface Soils, Subsurface Soils, Sediments, and Matte.
- ° Alternative 21 - Excavation of Battery Casing Components and Permanent Disposal in an On-Site RCRA Tumorus; Fixation or Stabilization of Surface Soils, Subsurface Soils, Sediments, and Matte.
- ° Alternative 25 - Permanent Disposal in an On-Site RCRA Tumorus of all Site Contaminated Materials, including Battery Casing Components, Surface Soils, Subsurface Soils, Sediments, and Matte.

These alternatives include an alternative requiring no long-term management of residuals (Alternative 10) and alternatives involving treatment as a principal element (Alternatives 10 and 21). In addition, containment alternatives (Alternatives 2A, 2B, 8, 21 and 25) are included, as well as a No-Action Alternative (Alternative 1). These alternatives were all carried through the detailed evaluation process.

The factors used to evaluate the Final Candidate Alternatives were effectiveness, implementability, and cost. Under effectiveness, consideration was given to the results of the endangerment assessment, as well as to categories of reliability, conformance to ARARs, and reduction in toxicity, mobility, or volume. Under implementability, factors considered were technical feasibility, constructability, performance, safety, time required to achieve remedial objective, permitting requirements, community concerns and institutional requirements. The cost factor included capital costs and operating and maintenance costs, as well as a present worth analysis at several different discount rates to evaluate the sensitivity of each alternative to inflation and general interest rates.

Pursuant to evaluation of the Final Candidate Alternatives, several engineering studies were performed to determine whether the SARA preference for treatment could be met. The engineering studies represented one category (technical feasibility) of one factor used to evaluate the Final Candidate Alternative. A soil stabilization study was performed by Weston Services, Inc. Weston used several different reagents to determine the applicability of the soil stabilization technique to Gould site soils and lake sediments. The results showed that admixtures of Portland cement, cement kiln dust, and lime kiln dust with the soil and

sediment at specific increments improved the consistency and structural stability of the soils and sediments, and also reduced the leachability of the contaminated materials to levels generally below hazardous waste designation levels.

Two battery casing separation tests were performed, and a third is planned after submittal of this Feasibility Study report. The two tests were performed on equipment manufactured by (1) MA Industries, Inc. and (2) Poly-Cycle Industries, Inc. To conduct each test, approximately twenty tons of material was shipped to locations where equipment manufactured by the two companies is in use. In the case of MA Industries, the test was run on equipment operated by Ace Battery Company of Indianapolis, Indiana. The test of Poly-Cycle equipment was run at the Poly-Cycle plant in Jacksonville, Texas. The equipment manufactured by the two companies is similar; however MA Industries is more oriented to equipment sales only, while Poly-Cycle's primary interest is in developing markets for the separated battery components.

The results for the first two tests were similar, but with different problems. During the Ace Battery test, extremely heavy foaming complicated the separation process and reduced its efficiency. During the Poly-Cycle test, an equipment problem affected the efficiency of metallic lead/ebonite separation. Reasonable physical separation of the plastic and ebonite components appears to be possible, although the post-separation degree of lead contamination of ebonite is so high that recycling is questionable. A second test at Poly-Cycle is planned to determine if the degree of physical separation of ebonite from metallic lead can be improved with equipment modifications. Of more importance, though, is the amount of lead contained in the interstices of the plastic and the ebonite. After separation, both components fail the TCLP test for lead. Ebonite fails badly even after washing with hydrochloric acid and deionized water.

During the evaluation of alternatives, similar tests were run independently by researchers working on materials from the United Scrap Lead Superfund site near Troy, Ohio. Researchers there performed bench-scale tests using various solutions and mechanical cleaning steps to determine the amenability of lead to be removed from the ebonite material. While no prediction can be made by extrapolating the laboratory results to field work, it appears that the process requirements would be of considerable scope and have significant environmental concerns. The researchers conclude that more work is required before the lab results could be applied to any field-scale unit. The results achieved to date

by NL Industries and Gould Inc. in their lab tests lead to the same conclusion.

Results reported to date show that great difficulty is encountered in attempting to reduce the interstitial lead content of the ebonite. Researchers have tried various combinations of separation steps, including physical, mechanical, and chemical steps, in addition to hand-separation at the outset. Even if laboratory methods do prove to be successful, the potential for successful field application of multi-step processes at the Gould site is far from assured.

The endangerment assessment referred to under the evaluation factor of effectiveness was designed to examine each alternative's performance under a number of different human and environmental exposure scenarios. Scenarios examined included on-site and off-site residential exposures, as well as on-site and off-site worker exposures. The contaminants examined were lead, arsenic, and cadmium. The health effects of arsenic and cadmium were examined from the standpoint of carcinogenicity, while the health effects of lead were evaluated in comparison to standards that result in no adverse chronic health effects. Aquatic species native to the Willamette River were discussed in the endangerment assessment as well.

A final consideration in evaluating alternatives was the range of institutional controls available to be applied to the site. As current owner, Gould Inc. retains rights to impose a number of controls on future use of the property. Most significant and relevant among these rights is the right to enter into binding covenants regarding sale and development of the property. Those rights were integrated into several of the alternatives as key elements of the remedial action. It should be noted that institutional controls are used for each of the alternatives.

The Feasibility Study concludes that Alternative 2B is the alternative most efficient in responding to risks posed by the site. This alternative would remove all surface piles of battery casings from the site, as well as capping the contaminated surface soils, thereby making unavailable for human contact by inhalation or ingestion all soils contaminated to levels that would fail the TCLP or EP Toxicity tests for lead. The East Doane Lake outlet to the Willamette would be blocked and the site would be graded away from the lake. As part of the alternative, Gould Inc. would covenant to hold the property in perpetuity and limit its use by executing an instrument binding on Gould Inc., as well as on its heirs and successors. The covenant would prevent contact with

contaminated ground water by forbidding installation of an on-site withdrawal well. In addition, the covenant would preclude any site development that might disturb contaminated source materials. Under SARA, such a structure for remediation is allowed if the remedial alternative can be shown to be equivalent to meeting ARARs for the site. Through the execution of this instrument, as well as through the technical remediation described for Alternative 2B, the waiver under Section 121 of SARA which permits remediation that does not meet ARARs if the alternative meets the equivalent of the ARARs is fully applicable to the Gould site. Moreover, perpetual control of the property by Gould Inc. would alleviate concern about exposure to ground water contaminated with dissolved lead above 0.05 mg/l. It is only in a small, stable area under the Gould site that dissolved lead exceeds such a level in the shallow aquifer system. Alternative 2B is shown, through the risk assessment, to adequately address any exposure scenario that would be reasonable given the institutional controls described above. It is concluded that the incremental benefit derived from implementation of more comprehensive remedial alternatives cannot possibly justify the tremendous cost differential apparent for those alternatives.

1.0 INTRODUCTION

This report presents the results of a Feasibility Study (FS) for NL Industries, Inc. and Gould Inc. as required by Administrative Order on Consent, EPA Docket No. 1085-05-08-106, dated August 29, 1985. The report supports activities under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), for a site currently owned by Gould Inc. and formerly owned by NL Industries, Inc. in Portland, Oregon.

The Gould site was included on the National Priorities List (NPL) in September 1983 in accordance with Section 105 of CERCLA. Site conditions leading to inclusion on the NPL stem from past operations as a battery recycling operation and secondary lead smelter during ownership by Morris P. Kirk & Son, Inc. from about 1949 to 1972, by NL Industries from 1972 to 1979, and by Gould from 1979 to 1981. NL Industries, Inc. and Gould Inc. have formally objected to inclusion of the site on the NPL (see Appendix D). Gould Inc., the current owner, ceased operations at the site in August 1981.

The project has been conducted in three phases. Phase A consisted of the Remedial Investigation (RI) for the site. Phase B identified remedial technologies potentially applicable to remediation at the site, and developed those technologies into remedial alternatives which addressed the range of site contamination conditions. Phase C provided a detailed evaluation and comparison of those alternatives. This FS report follows the submittal of a Draft Remedial Investigation Report on Phase A for the site on June 1, 1987 and submittal of a Final Remedial Investigation Report on November 16, 1987. A report on Phase B activities was submitted on June 5, 1987. The data generated during conduct of the RI are the basis for the development of remedial alternatives discussed in this FS report.

1.1 OBJECTIVE AND OVERVIEW

As required by the Work Plan developed pursuant to the Administrative Order on Consent, the objective of the FS is to develop and evaluate a range of remedial action alternatives for the site based on the findings of extent of contamination from the RI. The alternatives are screened and evaluated for factors of effectiveness, implementability, and cost. As a result of this evaluation, an alternative is recommended for implementation.

2.1 SCREENING CRITERIA AND METHODOLOGY

Comprehensive lists of remedial technologies, organized by general response categories, are presented in Guidance on Feasibility Studies Under CERCLA (EPA, 1985), and the Handbook, Remedial Action at Waste Disposal Sites (Revised) (EPA 1985). For the Gould site, these lists have been supplemented with information from a number of different sources, including Dames & Moore project experience files and extensive contacts with vendors and equipment users. From these sources, technologies suited to the Gould site were selected. The selection of appropriate technologies was guided by site conditions, and by the nature of the site contaminants. Selection was also guided by technical criteria based on direction provided in the National Oil and Hazardous Substances Contingency Plan as revised November 20, 1985, and was supported by a review of the technical literature and by the judgement of professional engineers.

2.1.1 Remedial Objectives

The remedial objectives discussed in Section 1.4 were used to determine the general response actions and to select the most appropriate remedial technologies. These objectives are:

1. To protect human health from effects of contaminants in public drinking water supplies.
2. To protect human health and the environment from detrimental effects of airborne metals contamination.
3. To protect human health and the environment from detrimental effects of contact with contaminated surface water or soils.
4. To protect the water quality of the Willamette River from degradation because of site contaminants.

2.1.2 Contaminant Characteristics and Site Conditions

At the Gould site, the hazardous substances directly associated with past site activities are lead, cadmium and arsenic. The RI for the site concluded that the most significant contaminant in quantity and distribution is lead. The RI also detected and confirmed the presence of organic contaminants at the site. The nature and distribution of the organic contaminants indicates that they are the result of activities elsewhere. Therefore, this FS does not address the health risk or the environmental degradation which may result from the presence of organic contaminants.

Site contaminants are distributed through a variety of materials in the study area. These materials have widely differing physical properties, and will likely require different treatment or handling techniques. Sources of lead in the fill include the battery casing fragments, the blast furnace matte, the surface and subsurface soils and the lake sediments.

Battery casing fragments on the Gould property are distributed aboveground in piles in the fill, and underwater in the East Doane Lake remnant. Fragments on the adjacent Rhone-Poulenc property are distributed in a layer 5 to 20 feet thick, buried under 5 to 6 feet of soil. The battery casing fragments are a mixture of metallic lead, lead oxide, plastic, and a hard rubber called ebonite. Most of the fragments are mixed with dirt and rocks, with trash from plant operations, with non-lead scrap metal, and with sweepings from zinc alloying operations.

The blast furnace matte is located on the Gould property, inside the boundary of the pre-1949 Doane Lake. Matte is a heavy, rock-like slag composed primarily of iron sulfides, together with trace metals such as antimony and lead. Most byproduct materials from the lead smelter, including blast furnace slag, speiss (lead arsenides or antimonides), baghouse dust, skimmings from the drossing (lead refining) kettles, and sweeping and cleaning materials from the smelter area, were returned to the blast furnace. The matte was therefore the only waste. Matte was originally discharged from the smelter in lumps of up to 10 inches cubed.

Soils and sediments contaminated by contact with fill materials constitute secondary sources of contamination. During the RI, the most highly contaminated surface soils were found in separate areas on the Gould and the Rhone-Poulenc properties. The most highly contaminated subsurface soils were detected near the battery casing fill. The most highly contaminated sediments were found in the East Doane Lake remnant.

The results of air modeling indicate that the offsite exposure to airborne lead from the site is within acceptable levels. This indication is based on modeling of fugitive dust (see Appendix A).

Overflow of the East Doane Lake remnant may transport site contaminants to the Willamette River. Offsite transport by surface water may result in exposure of aquatic organisms and recreational users to site contaminants. However, preliminary evaluations indicate that dilution of contaminants by the river will be significant, and will reduce the risk to acceptable levels.

Ground-water movement also may transport site contaminants from the shallow aquifer to the Willamette River, likewise resulting in exposure of aquatic organisms and recreational users to site contaminants. However, the Remedial Investigation demonstrated that no significant off-site transport of contaminants by ground water has yet occurred; nor is off-site transport likely to occur, due to adsorption and precipitation of dissolved contaminants in the soil.

Although direct ingestion of, or direct dermal contact with, site contaminants by the public appears unlikely due to the industrial nature of the area and to the lack of access to the site by children, exposure scenarios developed in the course of the site Endangerment Assessment examine these exposures, providing a basis for selection of a recommended remedial alternative.

2.2 IDENTIFICATION OF GENERAL RESPONSE ACTIONS

From the criteria established in Section 2.1, potential general response actions were developed. First, published lists of general response actions, together with typical means for completing the actions, were reviewed. In developing general response actions, technologies used for other hazardous waste site projects were also examined, as were innovative technologies. The potential general response actions thus identified are listed in Table 2.2-1.

2.2.1 No Action

The No-Action Alternative is not so much a category of technologies as a group of activities which can be used to address contamination problems when no additional remediation will take place. A major element in evaluating the No-Action Alternative is an estimate of the pattern of contaminant migration. Modeling of contaminant transport is often central to that estimate.

2.2.2 Control of Airborne Contaminant Migration

Airborne pollution from the Gould site consists of fugitive dusts. Fugitive dusts are particulates that are lifted from the ground by wind action. Entrained particulates carry lead and other contaminants from the site. Entrainment could occur at the site, or from contaminated soils carried by vehicles from the site to city streets. Excavation and other construction activities may substantially increase the generation

TABLE 2.2.1

GENERAL RESPONSE ACTION CATEGORIES AND
ASSOCIATED REMEDIAL TECHNOLOGIES

General Response Action	Technology
No Action	Air Quality Monitoring Monitoring of Wells Monitoring of Surface Water
Control of Airborne Contaminant Migration	Surface Treatment Removal of Surface Soils for Treatment or Disposal Removal of Battery Casings for Treatment or Disposal Installation of Wind Fences or Screens
Control of Surface Contamination	Surface Treatment Removal of Surface Soils for Treatment or Disposal Removal of Battery Casings for Treatment or Disposal
Control of Subsurface Contamination	Removal of Subsurface Soils for Treatment or Disposal Removal of Battery Casings for Treatment or Disposal Removal of Matte for Treatment or Disposal
Control of Contaminant Migration in Surface Water	Surface Treatment Surface Water Treatment Removal of Sediment for Treatment or Disposal Removal of Battery Casings for Treatment or Disposal
Control of Contaminant Migration in Ground Water	Surface Treatment Leachate Plume Barriers Ground-water Removal for Treatment and Disposal Water Treatment Removal of Sediment for Treatment or Disposal Removal of Battery Casings for Treatment or Disposal Removal of Matte for Treatment or Disposal

TABLE 2.2.1 (Continued)

General Response Action	Technology
Disposal of Treated Materials	Disposal of Treated Soils Disposal of Treated Sediments Disposal of Battery Casing Materials Disposal of Matte Disposal of Treated Water
Institutional Controls	Well Permit Restrictions Site Access Restrictions Land Use Restrictions Deed Restrictions

of fugitive dust at the site. The generation of fugitive dust by construction activities, as well as dust suppression techniques, is covered in Section 6.0, Detailed Evaluation of Remedial Alternatives, and will not be discussed further here.

Methods for controlling fugitive dust include the application of physical or chemical stabilizers, surface paving or capping, soil fixation or solidification, soil removal, revegetation, and wind fences or screens.

2.2.3 Control of Surface Contamination

Exposed contaminants at the Gould site may contribute to airborne pollution, leaching of contaminants to the ground water, contamination of surface runoff, and direct contaminant ingestion. Methods for mitigating surface contamination include some of the methods for controlling fugitive dust.

2.2.4 Control of Subsurface Contamination

It has been assumed that the subsurface contaminants are located inside a one-foot-thick layer of soil surrounding the casings and mat on both the Gould and Rhone-Poulenc properties. This assumption is based on sampling of the soil surrounding the fill, which demonstrated only isolated areas of high lead concentration. The underlying soil was originally Doane Lake sediments before placement of fill. Methods for controlling subsurface contamination include in-situ fixation, stabilization or vitrification, and soil removal for treatment and/or disposal.

2.2.5 Control of Contaminant Migration in Surface Water

Surface runoff and ponded surface water may leach site contaminants from surface soils, from exposed fill or from lake sediments. For the surface soils and the exposed fill, contaminant leaching may be controlled by the application of physical or chemical stabilizers, by surface paving or capping, by soil fixation or solidification, or by soil removal. Some of these controls may be applied to lake sediments, as well. It has been estimated that contaminants in the East Doane Lake remnant are contained within the first foot of sediments.

2.2.6 Control of Contaminant Migration in Ground Water

Ground-water movement may transport contaminants from the site to the surroundings, where aquatic organisms and recreational users may be exposed to them. Movement of ground water may be controlled by physical barriers to flow. Migration of contaminants in ground water may be controlled by treatment or removal of the contaminant source: that is, the fill, the sediments and the contaminated subsurface soil.

2.2.7 Institutional Controls

Institutional controls are local or state regulations that can be enacted and enforced to protect the public health in the vicinity of a hazardous waste site before, during or after remediation.

2.3 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

Concurrent with the identification of general response actions, which has been detailed above, technologies associated with the actions were determined. Feasible technologies are listed with the general response actions in Table 2.2-1. Most of the technologies listed are general categories, for which several specific technologies exist. A detailed list of the specific technologies is presented in Table 2.3-1.

This section explains the general response action categories, introduces and describes the associated remedial technologies outlined in Table 2.3-1, and presents the results of the technology screening process.

2.3.1 No Action

Description

Under the No-Action Alternative, a long-term monitoring program would be implemented to provide continuing information on contaminant migration. Surface water and groundwater would be sampled quarterly at monitoring wells. The monitoring program would include quarterly air quality monitoring, as well.

Initial Screening

There are insufficient grounds to dismiss the No-Action Alternative as infeasible or inappropriate at this time. Indeed, the alternative may be viable for portions of the Gould site. In accordance with the National Contingency Plan, the No-Action Alternative will be considered

TABLE 2.3-1

REMEDIAL ACTION TECHNOLOGIES APPLICABLE TO THE GOULD SITE

Page 1 of 10

I. No Action

A. Monitoring

1. Air Quality Monitoring
2. Monitoring Wells
3. Monitoring of Surface Water

II. Control of Airborne Contaminant Migration

A. Surface Treatment

1. Paving or Capping
 - a. Asphalt
 - b. Portland Cement
 - c. Layered Cover System
2. Fixation/Stabilization
 - a. Asphalt
 - b. Portland Cement
 - c. Lime Treatment
 - d. Pozzolanic Cementation
 - e. Proprietary Technologies
 - (1) Weston Services, Inc.
 - (2) Silicate Technologies, Inc.
3. Revegetation

B. Surface Soil Treatment/Disposal

1. Soil Removal for Treatment/Disposal
2. On-Site Treatment
 - a. Portland Cement
 - b. Lime Treatment
 - c. Thermoplastic Binding
 - d. Pozzolanic Cementation
 - e. Proprietary Technologies
 - (1) Weston Services, Inc.
 - (2) Silicate Technologies
 - (3) LOPAT Enterprises, Inc.
 - f. Soil Washing/Leaching
 - (1) Precipitation
 - (2) Acid or Base Leaching
 - (3) Chelation
 - g. In-Situ Treatment
 - (1) Solution Mining
 - (2) Weston Services, Inc.
 - (3) Silicate Technologies, Inc.

- 3. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
 - 4. Off-Site Disposal
- C. Battery Casings Treatment/Disposal
- 1. Casings Removal for Treatment/Disposal
 - 2. Recycle of Casing Materials
 - a. Component Separation
 - (1) MA Industries, Inc.
 - (2) Polycycle Industries
 - (3) Cal West
 - (4) Heavy Media Separation
 - b. Materials Recycling
 - (1) Lead
 - (2) Lead Oxide
 - (3) Plastic
 - (4) Ebonite
 - 3. Incineration of Casing Materials
 - 4. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
 - 5. Off-Site Disposal
- D. Installation of Wind Fences or Screens

III. Control of Surface Contamination

- A. Surface Treatment
- 1. Paving or Capping
 - a. Asphalt
 - b. Portland Cement
 - c. Layered Cover System
 - 2. Fixation/Stabilization
 - a. Asphalt
 - b. Portland Cement
 - c. Lime Treatment
 - d. Pozzolanic Cementation
 - e. Proprietary Technologies
 - (1) Weston Services, Inc.
 - (2) Silicate Technologies
 - 3. Revegetation

TABLE 2.3-1 (Continued)

- B. Surface Soil Treatment/Disposal
 - 1. Soil Removal for Treatment/Disposal
 - 2. On-Site Treatment
 - a. Portland Cement
 - b. Lime Treatment
 - c. Thermoplastic Binding
 - d. Pozzolanic Cementation
 - e. Proprietary Technologies
 - (1) Weston Services, Inc.
 - (2) Silicate Technologies
 - (3) LOPAT Enterprises, Inc.
 - f. Soil Washing/Leaching
 - (1) Precipitation
 - (2) Acid or Base Leaching
 - (3) Chelation
 - g. In-Situ Treatment
 - (1) Solution Mining
 - (2) Weston Services, Inc.
 - (3) Silicate Technologies, Inc.
 - 3. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
 - 4. Off-Site Disposal
- C. Battery Casings Treatment/Disposal
 - 1. Casings Removal for Treatment/Disposal
 - 2. Recycle of Casing Materials
 - a. Component Separation
 - (1) MA Industries, Inc.
 - (2) Polycycle Industries
 - (3) Cal West
 - (4) Heavy Media Separation
 - b. Materials Recycling
 - (1) Lead
 - (2) Lead Oxide
 - (3) Plastic
 - (4) Ebonite
 - 3. Incineration of Casing Materials
 - 4. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
 - 5. Off-Site Disposal

IV. Control of Subsurface Contamination

- A. Subsurface Soil Treatment/Disposal
 - 1. Soil Removal for Treatment/Disposal
 - 2. On-Site Treatment
 - a. Portland Cement
 - b. Lime Treatment
 - c. Thermoplastic Binding
 - d. Pozzolanic Cementation
 - e. Proprietary Technologies
 - (1) Weston Services, Inc.
 - (2) Silicate Technologies
 - (3) LOPAT Enterprises, Inc.
 - f. Soil Washing/Leaching
 - (1) Precipitation
 - (2) Acid or Base Leaching
 - (3) Chelation
 - g. In-Situ Treatment
 - (1) Solution Mining
 - (2) Weston Services, Inc.
 - (3) Silicate Technologies, Inc.
 - (4) In-Situ Vitrification
 - 3. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
 - 4. Off-Site Disposal
- B. Battery Casings Treatment/Disposal
 - 1. Casings Removal for Treatment/Disposal
 - 2. Recycle of Casing Materials
 - a. Component Separation
 - (1) MA Industries, Inc.
 - (2) Polycycle Industries
 - (3) Cal West
 - (4) Heavy Media Separation
 - b. Materials Recycling
 - (1) Lead
 - (2) Lead Oxide
 - (3) Plastic
 - (4) Ebonite
 - 3. Incineration of Casing Materials
 - 4. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
 - 5. Off-Site Disposal

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- C. Matte Treatment/Disposal
 - 1. Matte Removal for Treatment/Disposal
 - 2. On-Site Treatment
 - a. Portland Cement
 - b. Lime Treatment
 - c. Thermoplastic Binding
 - d. Pozzolanic Cementation
 - e. Proprietary Technologies
 - (1) Weston Services, Inc.
 - (2) Silicate Technologies
 - (3) LOPAT Enterprises, Inc.
 - f. Soil Washing/Leaching
 - (1) Precipitation
 - (2) Acid or Base Leaching
 - (3) Chelation
 - g. In-Situ Treatment
 - (1) Solution Mining
 - (2) Weston Services, Inc.
 - (3) Silicate Technologies, Inc.
 - (4) In-Situ Vitrification
 - 3. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
 - 4. Off-Site Disposal
 - V. Control of Contaminant Migration in Surface Water
 - A. Surface Treatment
 - 1. Paving or Capping
 - a. Asphalt
 - b. Portland Cement
 - c. Layered Cover System
 - 2. Fixation/Stabilization
 - a. Asphalt
 - b. Portland Cement
 - c. Lime Treatment
 - d. Pozzolanic Cementation
 - e. Proprietary Technologies
 - (1) Weston Services, Inc.
 - (2) Silicate Technologies, Inc.
 - 3. Revegetation

TABLE 2.3-1 (Continued)

- B. Surface Water Treatment
 - 1. Sedimentation
 - 2. Filtration
 - 3. Neutralization
 - 4. Precipitation
 - 5. Distillation
 - 6. Ion exchange
 - 7. Reverse Osmosis
- C. Sediment Treatment/Disposal
 - 1. Sediment Removal for Treatment/Disposal
 - 2. On-Site Treatment
 - a. Portland Cement
 - b. Lime Treatment
 - c. Thermoplastic Binding
 - d. Pozzolanic Cementation
 - e. Proprietary Technologies
 - (1) Weston Services, Inc.
 - (2) Silicate Technologies
 - (3) LOPAT Enterprises, Inc.
 - f. Soil Washing/Leaching
 - (1) Solution Mining
 - (2) Precipitation
 - (3) Acid or Base Leaching
 - (4) Chelation
 - 3. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
 - 4. Off-Site Disposal
- D. Battery Casing Treatment/Disposal
 - 1. Casings Removal for Treatment/Disposal
 - 2. Recycle of Casing Materials
 - a. Component Separation
 - (1) MA Industries, Inc.
 - (2) Polycycle Industries
 - (3) Cal West
 - (4) Heavy Media Separation
 - b. Materials Recycling
 - (1) Lead
 - (2) Lead Oxide
 - (3) Plastic
 - (4) Ebonite

TABLE 2.3-1 (Continued)

- 3. Incineration of Casing Materials
- 4. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
- 5. Off-Site Disposal

VI. Control of Contaminant Migration in Ground Water

- A. Surface Treatment
 - 1. Paving or Capping
 - a. Asphalt
 - b. Portland Cement
 - c. Layered Cover System
 - 2. Fixation/Stabilization
 - a. Asphalt
 - b. Portland Cement
 - c. Lime Treatment
 - d. Pozzolanic Cementation
 - e. Proprietary Technologies
 - (1) Weston Services, Inc.
 - (2) Silicate Technologies
 - 3. Revegetation
- B. Leachate Plume Barriers
 - 1. Slurry Walls
 - 2. Grout Curtains
 - 3. Sheet Pile Cutoff Walls
 - 4. Block Displacement Method
 - 5. Injection Recharge
- C. Groundwater Treatment/Disposal
 - 1. Groundwater Removal for Treatment
 - a. Pumping Systems
 - (1) Well Points
 - (2) Suction Wells
 - (3) Ejector Wells
 - b. Subsurface Drainage Systems
 - (1) Subsurface Drains
 - (2) Trenches
 - (3) Ejector Wells

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- 2. Groundwater Treatment
 - a. Sedimentation
 - b. Filtration
 - c. Neutralization
 - d. Precipitation
 - e. Distillation
 - f. Ion exchange
 - g. Reverse Osmosis
 - h. In-Situ Treatment
 - (1) Permeable Treatment Beds
 - (2) In-Situ Physical/Chemical Treatment
 - (3) In-Situ Vitrification
 - D. Sediment Treatment/Disposal
 - 1. Sediment Removal for Treatment/Disposal
 - 2. On-Site Treatment
 - a. Portland Cement
 - b. Lime Treatment
 - c. Thermoplastic Binding
 - d. Pozzolanic Cementation
 - e. Proprietary Technologies
 - (1) Weston Services, Inc.
 - (2) Silicate Technologies
 - (3) LOPAT Enterprises, Inc.
 - f. Soil Washing/Leaching
 - (1) Solution Mining
 - (2) Precipitation
 - (3) Acid or Base Leaching
 - (4) Chelation
 - 3. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
 - 4. Off-Site Disposal
 - E. Battery Casing Treatment/Disposal
 - 1. Casings Removal for Treatment
 - 2. Recycle of Casing Materials
 - a. Component Separation
 - (1) MA Industries, Inc.
 - (2) Polycycle Industries
 - (3) Cal West
 - (4) Heavy Media Separation
 - b. Materials Recycling
 - (1) Lead
 - (2) Lead Oxide
 - (3) Plastic
 - (4) Ebonite

- 3. Incineration of Casing Materials
- 4. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (24943) Untreated Material
 - b. Vault
- 5. Off-Site Disposal

VII. Disposal of Treated Materials

- A. Disposal of Treated Soils
 - 1. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
 - 2. Off-Site Disposal
- B. Disposal of Treated Sediments
 - 1. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
 - 2. Off-Site Disposal
- C. Disposal of Battery Casing Fragments
 - 1. Component Separation
 - a. MA Industries, Inc.
 - b. Polycycle Industries
 - c. Cal West
 - d. Heavy Media Separation
 - 2. Materials Recycling
 - a. Lead
 - b. Lead Oxide
 - c. Plastic
 - d. Ebonite
 - 3. Incineration of Casing Materials
 - 4. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
 - 5. Off-Site Disposal

TABLE 2.3-1 (Concluded)

Page 10 of 10

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- D. Disposal of Treated Matte
 - 1. On-Site Disposal
 - a. Landfill
 - (1) Treated Material
 - (2) Untreated Material
 - b. Vault
 - 2. Off-Site Disposal
 - E. Disposal of Treated Water
 - 1. Recharge of Treated Water
 - a. Well Points
 - b. Trenches
 - 2. Discharge to Water Body
 - a. Discharge to Willamette
 - b. Discharge to East Doane Lake Remnant
 - 3. Discharge to Sewer
 - 4. Evaporation
- VIII. Institutional Controls
- A. Well Permit Restrictions
 - B. Site Access Restrictions
 - C. Land Use Restrictions
 - D. Deed Restrictions
 - E. Sale Restrictions
-

further, during the detailed evaluation of the alternatives. The acceptability of this alternative will be judged in relation to the site contaminants and the hazards that they pose.

2.3.2 Surface Treatment Technologies

Identified response actions have the ability to control fugitive dust. However, not all technologies are applicable to all situations that require dust control. Land use around the site is industrial. Much of the fill on the Gould property is exposed. Vegetation would not be likely to survive on the exposed battery casing fragments; and wind fences or screens would not be effective on much of the site.

Dust entrainment is related to the surface crust. Physical and chemical stabilizers such as water, gravel or calcium chloride are temporary measures that decrease dust entrainment for a few hours to a month. Because their effect is temporary, physical and chemical stabilizers are not considered further, except in conjunction with dust control during construction.

2.3.2.1 Paving or Capping

Description

Paving or capping the site will effectively prevent the generation of fugitive dust, providing an impenetrable surface. There are many paving and capping techniques, most of which use multiple layers of compatible materials. These techniques also prevent the infiltration of surface water.

Paving can be of bituminous asphalt concrete or Portland cement concrete. Generally for traffic areas, paving consists of a well-compacted sublayer, a layer of aggregate, and at least one surface layer of either asphalt concrete or Portland cement concrete. The thickness of each layer is determined by the anticipated traffic load. For non-traffic areas, light-duty paving membranes may be sufficient. Sprayed bituminous membranes, generally one-quarter-inch thick, require special equipment for application. The asphalt is blown hot with a phosphoric catalyst, and solidifies as it cools. Sprayed membranes may be reinforced with polypropylene fabric underliners. They may also be pre-fabricated as bitumen-coated fiber mats reinforced with jute or hemp. For severe environments, sprayed sulfur membranes can substitute for asphalt or cement covers.

A cap can be a single layer of relatively impermeable and erosion-resistant material such as clay or silty clay. For example, bentonite is a natural clay which is composed primarily of montmorillonite, and which is extremely fine-grained and absorbent. Its properties make it suitable for mixing with soil and water to produce a low-permeability cap. Any clay cap must be kept moist to prevent cracking. This is usually accomplished by covering the cap with a layer of soil and vegetation.

Flexible synthetic membranes are made of polyvinyl chloride (PVC), chlorinated polyethylene (CPE), ethylene-propylene rubber, butyl rubber, hypalon and neoprene, or elasticized polyolefin. Thin sheets are available for producing cover liners. The sheets come in various widths which are overlaid and spliced in the field. Special welding techniques, adhesives and sealants are used to join the sheet edges.

Capping using clay, a sprayed membrane or a synthetic membrane will usually require a multi-layered system. Multi-layered covers may be arranged, from top to bottom, as follows:

1. Topsoil
2. Drainage layer
3. Barrier layer or membrane
4. Buffer layer
5. Contaminated soil

Layering is an effective technique that combines different materials to control water infiltration, to protect barrier layers, and to support vegetation. Requirements of RCRA stipulate that layered systems be used to cover landfills.

Initial Screening

Concrete and bituminous paving are vulnerable to cracking and chemical deterioration, but the cracks can be exposed, cleaned and repaired. Concrete covers have a design life of about 50 years. The cost of Portland cement concrete construction is relatively high compared to other methods, although maintenance costs are relatively low. The more exotic sulfur covers are not warranted by the type of contamination at the site. Sprayed or synthetic membranes are not durable enough to protect the site surface without a covering layer of vegetated top soil. Synthetic membranes have a maximum design life of about 20 years, but may be vulnerable to tearing, oxidation, burrowing animals and plant roots. On the other hand, membranes isolate the contaminated

soil from the actions of wind and surface water. Membranes may be used as part of a layered system, even though they require special placement and covering procedures.

Asphalt concrete, Portland cement concrete and layered cover systems have been retained for further consideration, during the detailed evaluation of the alternatives.

2.3.2.2 Fixation/Stabilization

Description

Fixation and stabilization techniques physically or chemically fix contaminants in a matrix. Some of the techniques result in a solid, stable material which can be used for dust suppression, whereas others result in a friable, soil-like material.

A common and accepted means of soil stabilization is addition of asphalt, Portland cement or flyash to create stronger soil bonds and thereby reduce dust. Portland cement and asphalt are suitable for mixing with sandy soils to stabilize and waterproof the soils. Procedures for mixing, spreading and compacting must be tailored to the site. For a soil-cement cover, approximately 8 percent by weight dry cement is blended into the soil with water, using a rotary hoe or a tiller. Intermittent sprinkling over several days may be required for adequate compaction and solidification.

Soils may also be treated with lime and/or flyash, both of which contribute pozzolanic (cementing) properties to the resulting mixture, optimize the grain size distribution and reduce soil shrinking and swelling. Lime applied as calcium oxide or hydroxide is suitable for cementing clayey soil. Also, addition of lime is recommended for neutralizing acidic cover soils, thereby reducing the ability of heavy metals to leach. If a synthetic liner is used, liner life can be extended by the addition of lime to supporting soil. Sands and gravels are more suited to treatment by a combination of lime and flyash than are clays. These materials are applied by rotary tilling, followed by water addition and compaction.

Flyash can be used as a soil additive, or as a cover layer. Essentially a silt with pozzolanic properties, flyash condenses as a boiler emission at coal-fired power plants and collects on electrostatic precipitators. Lime is usually added to flyash before placement.

A number of chemical stabilization methods have been formulated for treatment and disposal of hazardous wastes. These methods are often cement-, lime- or pozzolanic-based, and use special chemical additives. Some of the methods are proprietary. Besides suppressing fugitive dust, chemical stabilization methods may also prevent water erosion, limit contaminant solubility and/or detoxify the contaminant. Generally, the primary purpose of these methods is to prevent contaminant leaching.

A complete discussion of chemical stabilization methods is included in Section 2.3.3.2. Two of the proprietary methods discussed which are applicable as surface treatments are those of Weston Services, Inc. and of Silicate Technologies, Inc.

Initial Screening

Soil modified by addition of asphalt, cement, lime or flyash becomes rigid and susceptible to cracking, and will gradually disintegrate due to settling, freeze-thaw cycles and traffic. Therefore, these treatments are unsuitable for traffic areas. In non-traffic areas, limited durability will necessitate maintenance and replacement during the 30-year design period. Lime solidification may reduce the solubility of lead in surface and ground water; but it may also contribute to airborne dust emissions as it dries.

All of the surface treatment methods discussed above have been retained for further consideration, during the detailed evaluation of the alternatives.

2.3.2.3 Revegetation

Description

A vegetative cover may be a cost-effective means of stabilizing the surface of the site, when placement is preceded by surface sealing and grading. Vegetation decreases erosion and contributes to the development of a naturally fertile and stable surface environment. Also, revegetation will improve the appearance of the site.

Long-term vegetative stabilization involves the planting of grasses, legumes and shrubs. Grasses such as fescue and lovegrass, with dense root systems that anchor soil and reduce wind erosion, provide a quick and lasting ground cover. Legumes (lespedeza, vetch, clover, etc.) store nitrogen in their roots, enhancing soil fertility and assisting the growth of grasses. Shrubs such as bristly locust and autumn olive also provide a dense surface cover.

Initial Screening

Revegetation is very effective at reducing air pollution from fugitive dust when combined with some type of surface seal. Proper selection of plant species is imperative to avoid the need for excessive care and irrigation. Revegetation has been retained for further consideration.

2.3.2.4 Installation of Wind Fences or Screens

Description

In an area such as a topographic depression where there is no vehicular traffic, wind fences or screens can reduce the dispersion of fugitive dust. Screens of vegetation or fences which are relatively impermeable will deflect the wind from surface soils.

Initial Screening

Wind screens can be somewhat effective in reducing the dispersion of particulates from a site, provided the wind is moderate, and no traffic is allowed in the area. The Gould site is a moderately windy site without a strong prevailing wind direction. Given the uncertainty of effectively screening wind at the site, this approach has not been retained for further consideration.

2.3.3 Soil, Sediment and Matte Treatment Technologies

Contaminated fill at the Gould site may contribute to airborne pollution, leaching of contaminants to the ground water, contamination of surface runoff, and the availability of contaminants for direct ingestion. Options for treating fill materials include:

- ° Cementation with asphalt or Portland cement
- ° Lime treatment
- ° Thermoplastic Binding
- ° Pozzolanic Cementation
- ° Proprietary Technologies, i.e., Weston Services, Inc., Silicate Technologies, and LOPAT Enterprises, Inc.
- ° Soil Washing or Leaching by chemical precipitation, leaching with acid or base, or chelation
- ° In-Situ Treatment, i.e., solution mining, certain proprietary technologies (Weston Services, Inc. or Silicate Technologies, Inc.), or in-situ vitrification.

2.3.3.1 Fill Excavation for Treatment/Disposal

Excavation of the fill from the Gould site would be the first step for treating and restoring the material by other than in-situ methods, or for off-site disposal. Fill removal would achieve the remedial objectives listed in Section 2.1.1, eliminating specific contaminants and halting ground-water contamination due to leaching. However, excavation may temporarily increase the airborne dispersal of site contaminants due to the generation of fugitive dust. In addition, excavation may temporarily increase the leaching of contaminants to the surface and ground waters, due to mechanical agitation.

Conventional earthmoving machinery would be used to extract the contaminated fill. The placement of material, the required removal rate, and the degree of material segregation needed dictate which excavation methods can be employed. Required removal rate depends on treatment plant capacity, on the capacity of transport equipment and on cleanup schedule. The objectives in selecting an approach to excavation are: (1) to match the feed rate of treatment processes; (2) to choose equipment which can handle all of the fill materials; and (3) to provide compatibility with materials handling and transportation systems.

Excavation of contaminated surface soil is easily achieved because of the shallow depth of the required excavation. Surface soil may be removed using a wheel tractor-scraper, a dragline or a clamshell.

The selection of equipment for excavating the battery casing fragments must consider their placement. Casings are piled above grade on the Gould property, they are submerged in the East Doane Lake remnant, and they are layered under 5 or 6 feet of soil on the Rhone-Poulenc property. The coarse, granular texture of the casings eliminates certain removal options, such as pumps, vacuums and forklifts. Casings piled above grade can be removed with standard excavation equipment, such as wheel loaders, hydraulic front shovels, backhoe excavators, draglines, or clamshells, for subsequent feeding into treatment plant hoppers, conveying systems, or transport vehicles. Casings submerged in the East Doane Lake remnant must be handled by equipment capable of operating under water, such as backhoe excavators, draglines or clamshells. Casings buried on the Rhone-Poulenc property must first be uncovered by stripping away the covering soil. The soil cover may be removed using a wheel tractor-scraper, a dragline or a clamshell.

It is assumed that cleanup of sediments in the East Doane Lake remnant will require the removal of about one foot of the lake bottom. The

amount of material which must be removed will be determined by the permissible contaminant concentration levels, as determined by the endangerment assessment; and by field measurements. The sediment may contain rocks and battery casing fragments. Sediment may be removed using a dragline, or by dredging.

The RI concluded that site contaminants are for the most part bounded by a zone one foot thick surrounding the fill materials. Before the fill was placed, the soil in this zone was Doane Lake sediment. When the surmounting fill has been removed, the soil will be very similar to the existing lake sediment. The zone is well below the water table, and the soil permeability makes it impractical to dewater the material prior to excavation. Therefore, the method selected for excavating the sediments will also serve for excavating the subsurface soil.

Description

Wheel loaders are available in a range of sizes, mounted on rubber-tired wheels with diesel-powered, two- and four-wheel drive. A hydraulically-operated bucket is attached to the front of the tractor. The machine is therefore capable of self-loading, and can carry from 1 to 12 cubic yards of material per haul, depending on model. The tractors are highly mobile, perform well on flat to gentle slopes, and require moderate maneuvering space. Maintenance costs are comparatively low. They may easily be transported to or from the site, and are readily available for purchase or lease. Because of tractor mobility and range of bucket operation, loaded material placement is excellent.

Generally, use of wheel loaders is restricted to above or near the top of the water table. The tractor must be able to closely approach material which is to be loaded. In determining production output and costs, digging time, maneuvering time, transport time, dump time and return time must be considered. Wheel loaders can be used in combination with other excavation equipment to improve efficiency.

Hydraulic front shovels are especially suited to moving materials situated between 25 feet above to 9 feet below grade. Units are available mounted on crawler tracks, with front arm-and-bucket combinations that load about 2 to 4 cubic yards. They are available in both front and bottom dump configurations.

Backhoe excavators are similar in concept to hydraulic front shovels. However, a backhoe can excavate to a depth of 18 feet. They are available mounted on crawler tracks, and have a boom crane and buckets allowing loads of from 1 to 3 cubic yards.

Draglines use a boom crane with a bucket hung from cables and winches for excavation. The bucket is dropped empty into the excavation, and then dragged forward and upward toward the tractor. Dragline capacity is nearly limitless; however, a 4-cubic-yard bucket would be the largest practical volume for this site. Operating at 45 to 50 cycles per hour, such equipment could extract roughly 150 cubic yards of material per hour.

Like draglines, clamshells use a boom crane with a bucket hung from cables and winches. The bucket is dropped into the excavation in the open position, is closed around the material, and is removed full. A two-cubic-yard bucket at this site would operate at between 45 and 55 cycles per hour.

Wheel-tractor scrapers are drive tractors with an articulated scraper-hopper attached. The tractor pulls the scraper over an area, and a layer of material is scooped into the hopper. The tractor then drives to the dump site, where the hopper is emptied. Wheel-tractor scrapers have hopper capacities of from 20 to 40 cubic yards. They are limited to a grade of about 20 percent, but do not require an auxiliary materials transportation system.

A ladder dredge with an excavating head could be used to excavate submerged material. Ladder dredges are pontoon-supported structures that include a control house and the ladder support and winches. The ladder is attached to the supports and extends in front of the dredge. The ladder consists of an excavating head (usually a bucket wheel) and a pump for removing the excavated material. The ladder is lowered into the waste and the bucket train rotates, digging up the bed below the water line. Excavated material may be dewatered and stockpiled, or may be placed in wet storage.

Initial Screening

Because of the variety of waste locations, excavation using a wheel loader will require the support of transportation systems (conveyors or trucks) to move material. In addition, excavation of waste below grade will be restricted because of limits inherent in those systems: i.e., limited conveyor angle or limited slope. Additional earthmoving will be required to move the transportation system to a lower level. At the Gould site, use of a wheel loader may be restricted to surface and near-surface materials.

Like the wheel loader, hydraulic front shovels require auxiliary transportation systems for excavated materials. In addition, excavation

of waste below grade will be restricted because of limits inherent in the transportation system. Additional earthmoving will be required to move the transportation system to a lower level. Because hydraulic front shovels are expensive, they cannot be used effectively in combination with other equipment.

A dragline with a 60- to 70-foot boom crane can excavate to a depth of between 50 and 60 feet. Like the other equipment considered above, a dragline would require auxiliary materials transportation equipment. However, supporting transportation systems would not need to be moved to lower levels, reducing the need for additional earthmoving. Because of the suitability of the dragline for excavating fill at the Gould site, it is the prime candidate for extracting the battery casings, matte, sediment and soils.

A clamshell can excavate to a depth of 200 feet or more. Because of load limitations on the boom, a clamshell with the same capacity as a dragline will not have as long a reach. A clamshell also requires auxiliary materials transportation equipment. Because of the reduced boom reach, the supporting transport equipment would have to be moved more frequently than for a dragline. A clamshell may have difficulty extracting the hardened matte at the site. It is, however, a practical alternative for the battery casings and soils.

The wheel-tractor scraper is the most suitable unit for removing the soil covering from the battery casings on the Rhone-Poulenc property.

The major disadvantage of the ladder dredge is the amount of turbulence generated by its operation. Mechanical agitation of the sediments may contribute to leaching of contaminants into the surface water. In addition, the ladder dredge requires a complicated system of mooring lines, as well as a great deal of supporting equipment. These disadvantages, together with the relative unavailability of equipment, makes the ladder dredge an unlikely candidate for the removal of sediment from the site.

2.3.3.2 Surface Soil, Subsurface Soil, Sediment and Matte

Most of the processes for treating the site soils, sediment and matte require the extraction of material for batch or continuous treatment. A few may be performed in situ. Among the methods applicable to treating the waste materials are several proprietary technologies. The proprietary technologies provide enhancements of the basic fixation/

stabilization techniques. They often employ special chemical additives, and often are tailored to a specific pollutant. The proprietary methods considered include processes marketed by Weston Services, Inc., Silicate Technologies, Inc., and LOPAT Industries. The processes that may be performed in situ include fixation, soil washing techniques and in-situ vitrification.

2.3.3.2.1 On-Site Treatment: Fixation/Stabilization

Description

The purpose of fixing or stabilizing fill materials is to physically or chemically contain contaminants, preventing their transport by ground water or air. The various methods of fixation and stabilization are most successful when the stabilizing agents are thoroughly mixed with soil: this is most readily accomplished when the soils have been unearthed.

There are four general approaches to the fixation and stabilization of contaminated soil:

- ° Treatment with Portland Cement Concrete
- ° Lime Treatment
- ° Thermoplastic Binding
- ° Pozzolanic Cementation

A fifth approach, organic polymer binding, has been found ineffective in fixing metals in soil, and is not considered here.

Of the four approaches, treatment with Portland cement concrete is the least sensitive to variations in chemical makeup of the waste. The end product of cementation may be a monolithic solid, or may be a crumbly, soil-like material: physical properties depend on the ratio of soil to cement in the mixture. Cementation is very successful in treating metal contaminants because, at the pH of the cement mixture, most multivalent metal cations are bound up as insoluble hydroxides or carbonates. However, Portland cement concrete is sensitive to trace quantities of organics in soil.

Lime applied to soil neutralizes acidity, and supplies the soil with two essential nutrients: calcium and magnesium. For surface treatment, a maximum of six tons of lime per acre should be applied to mineral soils. No more than 4 tons of lime per acre should be applied at one time, as larger amounts are difficult to mix thoroughly. The pH of limed soils should be retested every three to four years.

Silicate Technologies has developed a fixation/stabilization method which uses a silicate additive known as Soilsorb HM. The additive is mixed with the waste material in a pug mill. The resulting mixture is roughly 15 weight percent additive, and within 24 hours sets up to a solid with a compressive strength of approximately 500 lb/in².

LOPAT Industries has developed a process called the K-20 Lead-In-Soil Control System. K-20 is a two-part compound that, together with lime, cement or cement kiln dust, chemically and physically interacts with lead and other toxic metals. K-20 operates by (1) penetrating the soil substrate to form a polymer seal, (2) fixing the metals by precipitation as insoluble silicates, and (3) encapsulating the precipitated metal silicates in a cement-like matrix. The manufacturer claims successful application of the product to incinerator and cement kiln ash, furnace slag, metal salvage waste, sludge and soil.

Initial Screening

Each of the cementation techniques appears to be feasible for remediating the Gould site, and has been retained for further consideration during the detailed evaluation of the alternatives.

Lime treatment may effectively reduce lead transport from the site by raising the pH of water infiltrating the fill, thereby reducing lead solubility. Thermodynamic considerations alone suggest that lead solubility could be reduced to less than 20 ug/L for a soil pH of between 8.2 and 9.1. Lime treatment has been retained for further consideration.

Thermoplastic binding should generally be applied to dried waste. Otherwise, energy beyond that required for fixation must be supplied during treatment in order to drive off water. Because much of the fill at the site is below the water table, dewatering would demand a substantial effort. This technology therefore appears economically infeasible relative to the others considered, and it will not be considered further.

During the RI, bench-scale tests were conducted by Weston Services, Inc. on soil and sediment from the Gould site (see Section 5.5). Test results suggest that admixtures of soil and sediment with Portland cement, cement kiln dust and lime kiln dust reduces leaching of lead from these materials. The structural stability and consistency of the materials were improved, as well.

Testing analogous to that conducted by Weston Services, Inc. was not attempted for the Silicate Technologies, Inc. stabilization method. Yet, the two methods are similar enough that the positive results from Weston can be taken to imply that the Silicate Technologies method could also reduce leaching of lead from contaminated materials from the Gould site.

Some testing was performed on the LOPAT K-20 Lead-In-Soil Control Mixture. During the RI, coating tests were performed using this product, as well as some other coating materials. The purpose of the tests was to determine if an external coating of the K-20 mixture could reduce leachable lead from battery casing fragments to below EP Toxicity levels. The K-20 mixture failed. However, this test does not justify eliminating the K-20 treatment from further consideration, since (1) it is being considered for the treatment of soil, sediment and matte, rather than battery casing fragments, and (2) the test may not have applied the treatment in strict accordance with the manufacturer's instructions.

2.3.3.2.2 On-Site Treatment: Soil Washing/Leaching

Description

Contaminants can be washed from soils, using water or an aqueous solution of acid, base, chelating agent, oxidizing agent or surfactant. The various methods of soil washing are most successful when the soils have been unearthed. An agitation leaching process is depicted in Figure 2.3-1. In this process, acids or bases are used to flush metals from soil. Excavated materials are fed through an apron feeder and belt conveyor into a hopper. The materials are then mixed with the leach solution in continuously stirred leaching tanks. As the contaminants are drawn into the liquid phase, they are removed for extraction by precipitation, generally brought on by pH adjustment. The stripped leach solution is either recycled or treated for disposal. The washed soil is disposed of by backfilling on-site or by placement in a landfill.

EDTA or other chelating agents can be used to remove metals from soils. Excavated contaminated soils are mixed with a solution containing the chelating agent, forming a slurry. The slurry is then centrifuged to separate the clean soil from the metal-contaminated liquid. The chelating agent is chemically regenerated by extraction of the metals.

Initial Screening

Acid leaching has been successfully demonstrated in mining operations, in the extraction of metals from bulk materials. This method has been retained for further consideration.

Chelation processes are largely experimental, and the data available on their effectiveness is not adequate for determining how they might perform at the Gould site. In terms of effectiveness of economics, no advantage for chelation processes over acid leaching is apparent. These processes will not be considered further.

2.3.3.2.3 In-Situ Treatment

Description

As noted above, contaminants can be washed from soils in place, using water or an aqueous solution of acid, base, chelating agent, oxidizing agent or surfactant. The contaminants are flushed into the ground water, which is then collected for treatment. Flushing with an acid or base is generally known as solution mining.

Both the Weston Services, Inc. and the Silicate Technologies, Inc. methods can be applied in-situ. In practice, the methods would be only partially in-situ, since extensive excavation and soil movement would accompany removal of the battery casings.

Pacific Northwest Laboratories (PNL) has developed an innovative soil-melting technology which it has named in-situ vitrification. The process passes an electric current through the soil, between two electrodes set in the ground. The resistance of the soil to electric current generates enough heat to decompose organic contaminants and melt soil and rock, sealing residues and metallic contaminants into a glass-like matrix. Materials within the melt are uniformly mixed by convection currents. Gases evolved by the process are captured by an off-gas collection and treatment system.

Initial Screening

The RI indicated that lead in the soil has not migrated substantially since placement of the fill. It is likely that lead solubilized from the fill has adsorbed onto soil particles. Given the low solubility of lead in general, it seems doubtful that solution mining using a dilute acid can successfully desorb the lead in the soil, or adequately mobilize lead in the fill for its extraction in groundwater. In addi-

tion, the introduction of chemicals into the site fill risks their introduction into the ground water. Solution mining therefore appears inapplicable to this site, and it will not be considered further.

While fixation and stabilization techniques will be most successful when applied to excavated soils, there are insufficient grounds for dismissing in-situ fixation/stabilization methods as infeasible or inappropriate at this time. Therefore, these methods have been retained for further consideration during the detailed evaluation of the alternatives.

In-situ vitrification has been successfully tested at the Hanford site. However, the method is still experimental, and further testing must take place before routine application of the process to hazardous waste cleanup. Also, the power required by the process makes this an expensive technology. In-situ vitrification will not be considered further.

2.3.3.3 Battery Casings

2.3.3.3.1 Recycle of Casing Materials

Recycling of materials mixed into the battery casing fragments contributes towards achieving the remedial objectives listed in Section 2.1.1. Recycling also reduces the quantity of material that must be disposed of as hazardous waste. In addition, recycling offers the benefit of obtaining a product from the waste which may have a higher economic value than the waste itself.

COMPONENT SEPARATION

Description

The first step in recycling any of the materials mixed into the battery casing fragments is component separation. Equipment for battery recycling is available and in use; however, separation of materials from the fragments on the site is different than separation of materials from whole batteries. As part of this FS, some testing of existing battery recycling equipment was performed (see Section 5). That testing was somewhat inconclusive, but indicated that additional modification of available equipment will probably be necessary before on-site separation can be considered a practical technology.

MA Industries, Inc. of Peachtree City, Georgia, manufactures two systems for battery reclamation and classification. The complete system

is designed to crush and classify whole, undrained lead acid batteries. The Top Case system is designed to classify only tops and cases. The complete system can process from 4.4 to 35.0 tons of batteries per hour; the Top Case system can process from 3.4 to 7.7 tons of tops and cases per hour. A generalized flow diagram for the MA Industries systems is provided in Figure 2.3-2. Operation proceeds as follows:

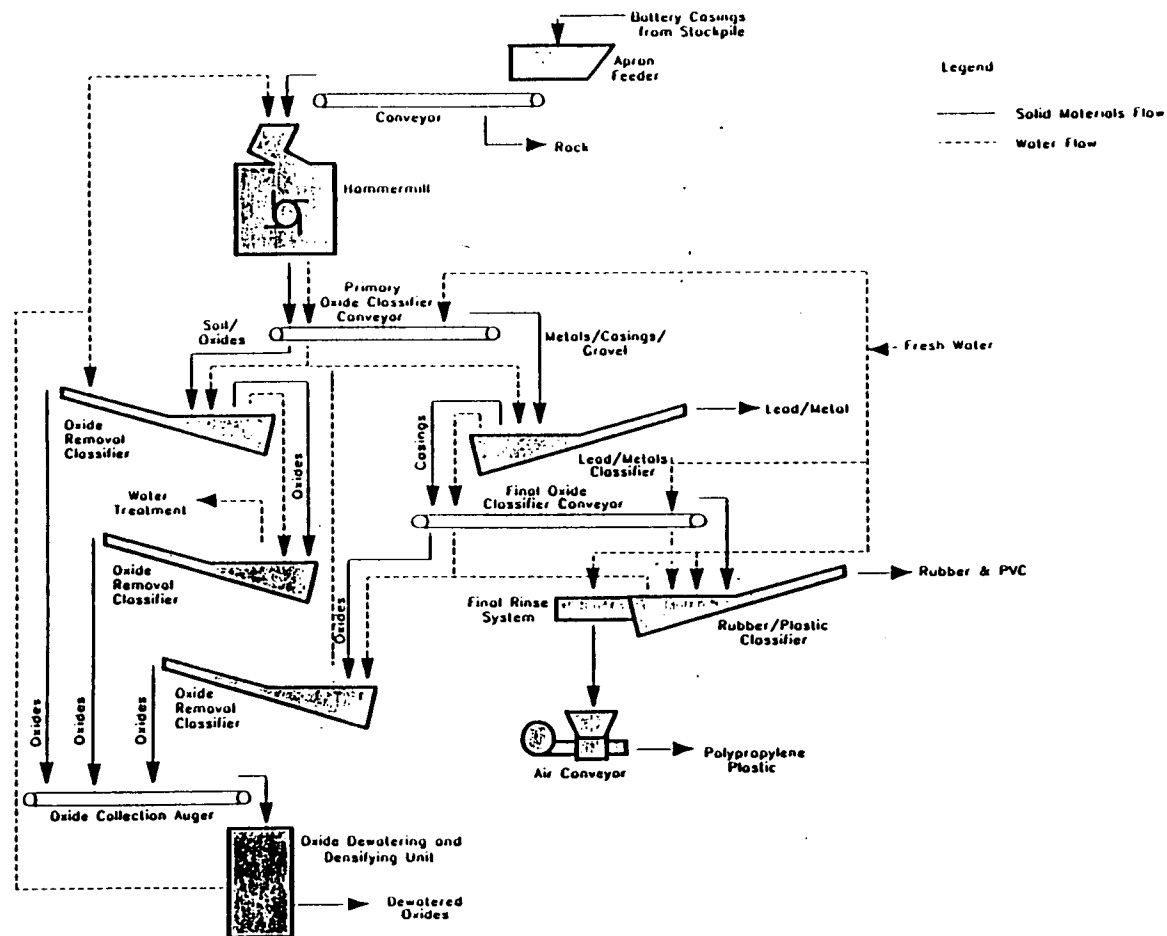
1. Either whole batteries or just tops and cases are fed into a stainless steel hammermill crusher. In order to reduce dust and control airborne lead, water is sprayed into the hammermill with the feed materials.
2. Product from the hammermill is directed to a screen conveyor. Lead oxide passes through the screen, and is routed to a series of wet oxide classifiers. After classifying, separated oxides may be dewatered and densified in an optional dewatering unit.
3. Lead metal is separated from the battery casing fragments by settling in a wet classifier. The fragments are washed on a second screen conveyor to remove any residual lead oxide.
4. Plastic is separated from ebonite in an agitated flotation tank. These two materials are then washed with fresh water.

Product streams from the MA Industries machines are lead, lead oxide, plastic and ebonite. The wet classification system reduces dust generation to a minimum. Stainless steel construction reduces equipment corrosion due to contact with battery acid. Efficient water use is achieved through recycle. Additional water savings can be realized through water treatment in an optional treatment facility.

Battery separation machines are also available through Polycycle Industries and Cal West. Cal West is reported to use processes that are similar to those used by the MA Industries machines.

The Polycycle process is not fundamentally different from MA Industries, but the sequence of steps and equipment show variation. The Polycycle process is described below:

1. Whole batteries or battery fragments are fed into a hammermill crusher. A water spray reduces airborne lead.
2. From the crusher, the material is passed through a wet classifier. Three material streams exit the classifier: a) plastic; b) combination of ebonite and lead; and c) combination of lead



NL IND. INC./GOULD INC. FEASIBILITY STUDY
HYDRO-CLASSIFICATION SYSTEM
FIG. 2.3-2 DAMES & MOORE

oxide, dirt, mud and small dense debris (rock, etc.). Plastic and lead oxide are recycled.

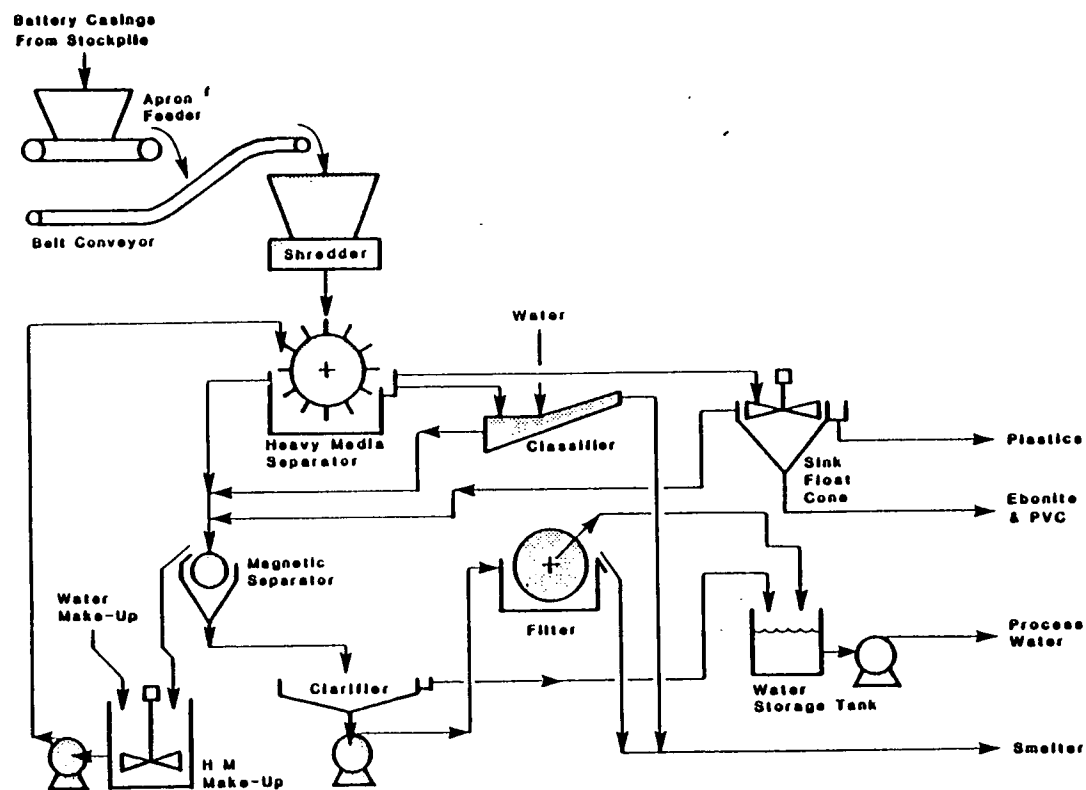
3. The ebonite/lead stream is washed to remove any remaining lead oxide or dirt; the material is then dried.
4. After drying, the ebonite/lead is passed through a dry separator. Lead is recycled.
5. Ebonite is ground to a coarse, medium, or fine particle size, then packaged for recycling.

Another method that is very effective in separating solids of differing specific gravities is heavy-media separation. Separation is accomplished using a fine-grained solid of high specific gravity, suspended in liquid. Solids of a sufficiently high specific gravity that are introduced into the suspension sink, while solids of a low specific gravity float. The method is extensively used for beneficiating ores, and is finding increasing use in the processing of shredded automobile scrap (R. H. Perry and C. H. Chilton, 1985). Heavy-media separation plants are usually custom-designed for their specific application.

A heavy-media separation plant is illustrated in Figure 2.3-3. The plant includes a shredder, a heavy-media separator, a spiral classifier, a sink/float cone, a magnetic separator, a clarifier and a make-up system for the heavy-media suspension. The shredder reduces battery casing fragments to roughly 1/4-in. Fragments discharged from the shredder into the heavy-media separator mix with a magnetite and water suspension having a specific gravity of 1.7. Lead and lead oxide sink through the separator and are removed by a bucket wheel. The lead and lead oxide pass to a spiral classifier, where they are separated from the magnetite slurry. Plastic and ebonite float, and are skimmed off and discharged to a sink/float cone. The sink/float cone uses water to separate the plastic from the ebonite. Magnetite is recovered from the heavy-media separator, the spiral classifier and the sink/float cone by a magnetic separator. Water from the magnetic separator is clarified to remove residual lead and lead oxide.

Initial Screening

Each of the hydro-classification systems marketed by MA Industries, Inc., Polycycle Industries, and Cal West may be capable of separating the components of the battery casing fill at the Gould site. MA Industries is the apparent leader in the battery recycling industry.



NL IND. INC./GOULD INC.	
FEASIBILITY STUDY	
HEAVY MEDIA SEPARATION	
FIG. 2.3-3	DAMES & MOORE

Polycycle has designed and sold several recycling and classification systems and has developed a marketing capability for material recycle. Cal West units are of an older design than the MA Industries machines. The hydro-classification concept has been retained for further consideration.

Heavy-media separation is not effective for separating material containing a substantial fraction of material that is less than about 0.5 mm. Analyses of fill particle-size distributions conducted during the RI show that much of the fill is smaller than 0.5 mm. Therefore, heavy-media separation will not be effective at separating site fill. This technology will not be considered further.

MATERIALS RECYCLING

Description

The primary materials contained in the battery casing fragments - lead, lead oxide, plastic, ebonite and matte-all bear the potential for reuse, provided that they can be adequately separated. Lead and lead oxide may be recycled through a primary or secondary lead smelter. Plastic may be sold as a feed stock to the operators of injection molding facilities. Ebonite is potentially recyclable for its heat content, or for use as an additive for special applications. Even matte may potentially be crushed and added to the lead oxide for recycling through a smelter.

Because the heat content of ebonite is about 12,000 Btu/lb, its use as a fuel could provide an economic return, as well as reducing the quantity of fill that must be disposed of as hazardous waste. ASARCO operates a primary lead smelter at their East Helena plant. There, the firm manufactures lead bullion from ores and concentrates. Battery casing fragments could be used as blending materials for the feed to the plant blast furnace or reverberatory furnace. The heat content of the casings would offset furnace fuel requirements. In addition, lead contaminants would be captured in the plant lead product, while silica in the soil might be a useful fluxing agent. Cement kilns capable of burning solid fuel may also be capable of burning pulverized battery casings as auxiliary fuel in their rotary kilns. The heat content of the battery casing fragments would be used by the kiln, and residual lead would be diluted in the cement product.

Polycycle Industries has developed a process for converting ebonite into several products which are useful for drilling wells for oil, gas

and sulfur. The products are added to drilling fluids, are employed as lubricants and are used as an additive for cement. However, low petroleum prices have discouraged well-drilling activities, lessening the demand for the Polycycle products.

Ebonite could also be ground up for use as an asphalt additive for application to road surfaces.

Initial Screening

Recycle of all of the components of the battery casing fragments is possible, and has been retained for further consideration. Recycling possibilities, however, depend on the level of component separation that can be attained. Recycle of lead oxide through secondary lead smelters requires a purity of at least 80 percent. Recycle of plastic by the operators of injection molding facilities will require an even higher degree of purity.

Of the recycling options, recycling of ebonite will be the most difficult. Recycling of ebonite would be attractive if viable, especially since the ebonite is the largest portion of the battery casing mixture. This alternative has been retained for further consideration. The reuse of ebonite in asphalt would also be attractive if viable, since a product of increased economic value would be obtained. This alternative, too, has been retained for further consideration.

There are elements in the ASARCO organization that consider incineration of the ebonite a liability, and that are opposed to accepting it. It is evident from discussions with ASARCO that no credit will be provided for the heat value in the casings. In view of the reluctance of the firm to accept the casings, this recycling option will not be considered further.

In preliminary discussions regarding battery casing incineration, Canada Cement Lafarge have indicated that to be used as fuel, recycled material must have a lead content of no more than 0.25 percent, and a lower lead content may be stipulated. The degree of separation of battery casing fragments from soil which the cement kiln may require is not known at present. Also, the practicality of reducing the battery casing fragments to the size required for cement kiln feed is not known at present. Casing incineration at a cement kiln has been retained for further consideration, although there may be administrative difficulties in exporting materials to Canada Cement Lafarge (see Appendix D).

Recycling of matte is the most tenuous at this time. Representatives of Polycycle have indicated the possibility of using matte to enhance the lead content of lead oxide prior to smelting. No commitment have been sought obtained.

Of key importance to the issue of recycling is an interpretation of the regulatory status of materials to be recycled. Materials designated as hazardous waste are inherently more difficult to recycle because of the requirement for the recycling facility to obtain a RCRA Treatment, Storage and Disposal (TSD) permit, and operate the facility in accordance with the requirements of 40 CFR Part 264.

NL Industries and Gould have sought clarification of the EPA position on recycling Gould site materials. The EPA position is provided in a letter contained in Appendix D.

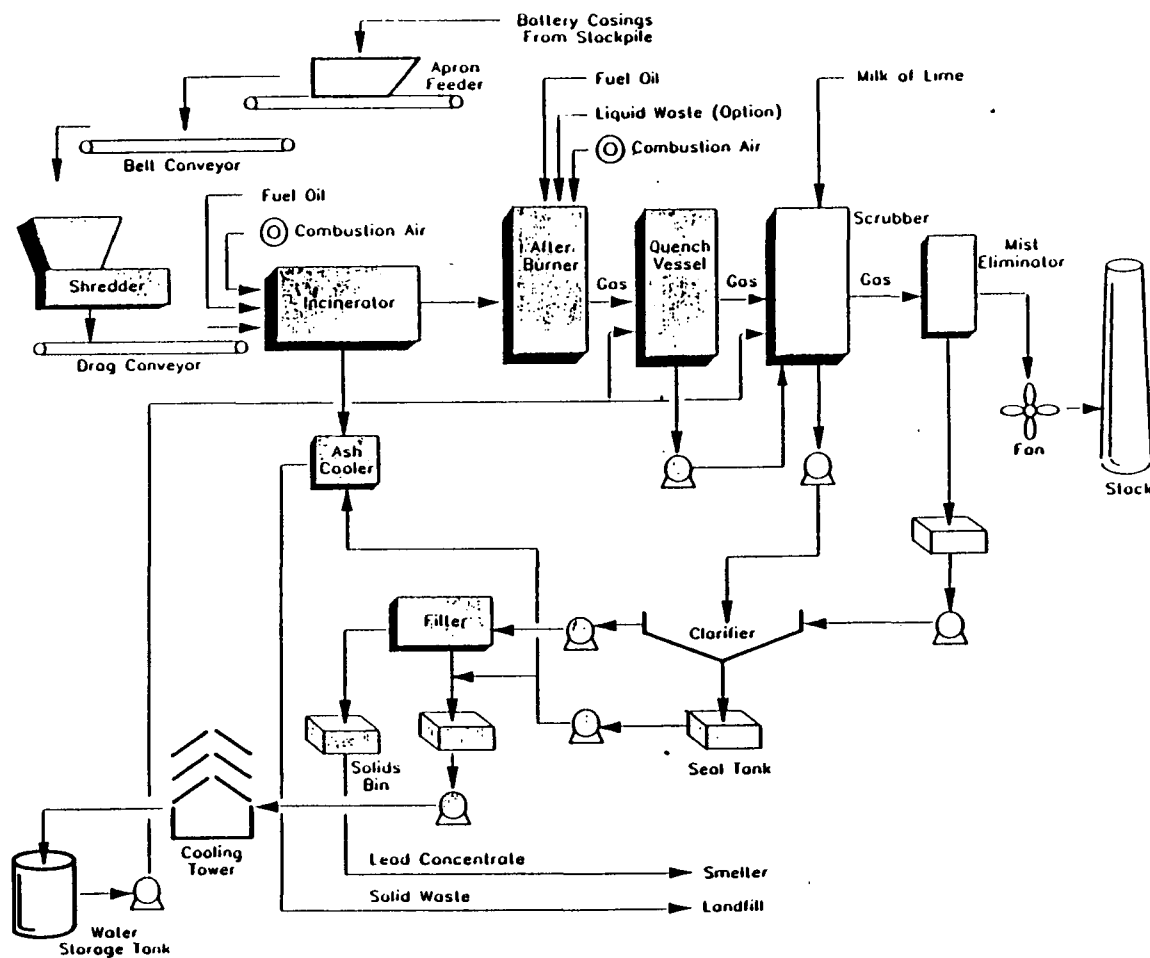
2.3.3.3.2 Incineration of Casing Materials

As discussed above, incineration may recover heat value from the battery casing fragments. Incineration may also be used to burn off the combustible portions of the fragments, reducing the volume which must be disposed of as hazardous waste.

Description

A mobile incineration system, such as the Shirco Infrared Processing System, could be operated on site to incinerate the battery casing fragments. A process flow diagram of a typical mobile incineration system is provided in Figure 2.3-4. Such a system could process between 100 and 250 tons of battery casings a day. The system consists of four components: an electric-powered infrared primary furnace, which operates at up to 1850°F.; an infrared or gas-fired afterburner, which operates at temperatures near 2300°F.; an emission control system; and the process controls. These mobile incineration systems can be operated to perform either combustion or pyrolysis.

Pyrolysis can be used to glassify waste, rendering it chemically stable. A glassification system consists of a glass media feed system, a glass furnace, a scrubbing system, and a granulation system. Waste is fed into the furnace with the glass, where the two are melted. The glass bed in the furnace is agitated continuously by air, promoting the uniform mixing of the waste and the glass. The glass product is discharged to a granulation chute, where it is quenched with water. Off-gasses from the furnace are cleaned in a scrubber before discharge to the atmosphere.



NL IND. INC./GOULD INC. FEASIBILITY STUDY	
INCINERATION SYSTEM	
FIG. 2.3-4	DAMES & MOORE

Initial Screening

Serious doubts exist about whether lead emissions from the incineration of battery casing fragments could be adequately controlled. However, combustion of battery casing fragments has been retained for further consideration. Glassification, on the other hand, will not be considered further, due to its higher energy demands and increased costs.

2.3.4 Water Treatment Technologies

2.3.4.1 Ground-Water Removal for Treatment

In remedying a hazardous waste site, ground-water extraction can be used for plume interception and containment, for water removal for treatment, or for gradient modification. Gradient modification consists of altering the ground-water flow by drawing down the water table at a point, forming a cone of depression. The altered water table effects the flow of ground-water contaminants, leading them to the low point for extraction and treatment or disposal. The areal extent and the gradient of the cone of depression depends on extraction rate and duration, and on properties of the aquifer.

Description

Contaminated ground water can be extracted from the earth by several means. Pumping systems such as well points, suction wells and ejector wells can perform plume interception, water removal or gradient modification. A well point system consists of a series of riser pipes which are screened at the bottom and joined to a common manifold and a suction pump. They are practical in shallow aquifers up to 30 feet deep. Individual well points must be close enough that sufficient drawdown is maintained between the wells: typical spacing is between 3 and 7 feet. A suction well extracts ground water at a single point, using a suction pump. Operating characteristics of a suction well are similar to those of a well point. An ejector well provides ground-water extraction at depths beyond the head limit of suction systems. Well and pump design are based on the well depth and desired rate of water extraction. Often, submersible pumps are used.

Subsurface drains are constructed of tile or perforated pipe, placed in a trench surrounded by gravel or similar material, and covered with topsoil or clay. Subsurface drainage systems have been used to dewater agricultural and construction sites. At an uncontrolled hazar-

dous waste site, subsurface drains can be installed to collect leachate, as well as to lower the water table.

Initial Screening

Extraction of contaminated ground water from the shallow aquifers underlying the site could be accomplished by one or more of the pumping systems discussed. Placement of pumping wells downgradient of the site could prevent the migration of contamination from the site through the shallow aquifers. For this purpose, an ejector well would not be necessary, since the shallow aquifers lie at depths of 30 feet or less.

A large portion of the infiltrating water flows vertically through the basalt bedrock, rather than horizontally through the shallow aquifers. Pumping systems could not readily be placed to intercept this vertical flow. Pumping systems would therefore not accomplish the remedial objective of controlling contaminant migration in ground water. Pumping systems could be used to control the migration of contaminants leached from the fill during excavation or treatment operations. For this purpose, they have been retained for further consideration. Pumping systems could also be used to remove ground water contaminated above acceptable levels for treatment and disposal.

Gravity collection systems such as subsurface drains, trenches and ejector wells can intercept ground water near the surface. The interception of vertical flow through the basalt, however, would require tile or pipe placement under most of the site. This placement would result in the uncontrolled drainage of contaminated water during construction. Gravity collection systems will not be considered further.

2.3.4.2 Control of Groundwater Migration

Leachate plume barriers consisting of a vertical wall of low-permeability materials can be constructed underground to divert groundwater flow, or to reduce or restrict the movement of a contaminant plume. At the Gould site, leachate plume barriers could be used to divert uncontaminated ground water around the filled areas or to provide a hydrologic containment for a ground-water treatment system. Five methods are available for producing a barrier:

- ° Slurry Walls
- ° Grout Curtains
- ° Sheet Pile Cut-off Walls
- ° Block Displacement Method
- ° Injection Recharge

Description

A slurry wall is a fixed underground barrier that is constructed in a vertical trench which is excavated under a slurry. The slurry, which is usually a mixture of bentonite and water, hydraulically supports the trench to prevent its collapse. At the same time, the slurry forms a filter cake on the trench walls, preventing excessive fluid losses to the surrounding soil. Once the trench is excavated, the barrier can be formed by blending soil with the bentonite mixture. In some cases, the trench is constructed under a slurry of Portland cement, bentonite and water, and the barrier is formed simply by allowing the mixture to harden in place. If great strength is needed, the barrier can be constructed of pre-cast or cast-in-place concrete panels, forming a diaphragm wall.

A grout curtain is an underground barrier produced by injecting grout into the soil through well points. Injection points are usually arranged in two off-set rows. The grout can be a particulate such as Portland cement concrete, or a chemical such as sodium silicate.

Sheet pile cutoff walls are constructed of webbed sections of sheet piling which are driven into the ground. Individual sheets are locked together by a socket-and-ball or a bowl-and-ball joint. On initial installation, the joints between sheets are not water-tight; however, the joints soon fill with fine- to medium-grained soil particles, which tend to block ground-water flow. The sheet piling can be steel, concrete or wood. Sheet pile cutoff walls are typically used in soils that are loosely packed and consist largely of sand and gravel.

The Block Displacement Method places a fixed underground barrier around and underneath a block of earth. Injection holes are drilled into the earth surrounding the site. A slurry forced into the base of the holes produces a large uplift pressure on the surrounded block. The uplift pressure fractures the area under the block, raises it, and fills the resulting void with the slurry. The injected slurry thus forms a horizontal barrier under the block. Perimeter barriers are formed by the conventional techniques of slurry wall, grout curtain or sheet piling placement.

Injection of water into an aquifer or an overlying impermeable stratum can affect ground-water movement. Water injection can cause mounding, a localized increase in the hydraulic head of the water table, near the point of injection. Redirection of ground water can also effect the movement of a contaminant plume.

Initial Screening

At the Gould site, a slurry wall, grout curtain or sheet piling could be locked into the underlying basalt. Placement of one of these barriers upgradient of the site could prevent lateral infiltration into the fill, while placement downgradient of the site could prevent lateral migration into the aquifer. Enclosure of the fill by one of these barriers could reduce the amount of water requiring treatment.

A slurry wall can be a cost-effective means of reducing leachate migration, and of assisting the operation of a ground-water treatment system. This technology has been retained for further consideration.

A grout curtain can be several times more expensive than a slurry wall. It can be successfully applied only under certain soil conditions, and is generally unable to greatly reduce the permeability of unconsolidated soils. This technology will not be considered further.

Sheet-pile cut-off walls can be costly, and damage to or deflection of the pilings in rocky soil will reduce their effectiveness. They are seldom used, except to limit erosion by surface water which has been diverted by another barrier, or for temporary dewatering during construction. Sheet-pile cut-off walls will not be considered further.

The Block Displacement Method is most useful when underlying strata are not sufficiently near the surface for a perimeter barrier alone to isolate the waste. This condition does not apply to the Gould site; the method will not be further considered.

Injection of water to modify ground-water flow patterns could reduce the lateral infiltration of ground water into the site fill. Water for injection recharge might be available from the Willamette River, from the city water system or from wells in the aquifer upgradient of the site. Injection recharge using trenches or galleries is not considered practical, given the shallow depth of the ground-water table. Injection by recharge wells, however, is feasible, and has been retained for further consideration.

2.3.4.3 Water Treatment

A number of technologies exist for treating water for inorganic contaminants. Technologies which may be applied to contaminants at the Gould site are:

- ° Sedimentation
- ° Filtration

- ° Neutralization
- ° Precipitation
- ° Distillation
- ° Ion Exchange
- ° Reverse Osmosis
- ° In-Situ Treatment: i.e., permeable treatment beds, in-situ physical or chemical treatment, or in-situ vitrification.

Description

Sedimentation removes suspended particles from an aqueous stream by promoting the settling of solids under the influence of gravity. In conventional industrial waste water treatment, sedimentation can reduce total suspended solids to between 10 and 200 mg/L, corresponding to a removal efficiency of better than 90 percent. Flocculating agents are often used to enhance the settling of particulates.

Filtration is the physical separation of solids and liquids on a porous medium. For hazardous waste treatment, filtration can perform three functions: 1) liquid purification by the removal of suspended solids; 2) dewatering for the volume reduction of waste sludges; and 3) filtration to remove particulates from a stream prior to sensitive treatment processes. In all filtration systems, pressure or suction is required to force liquid through the filter medium. Removal of solids from the filter medium must also be considered. Generally, filtration is successful at removing particles larger than 25 microns: smaller particles must be agglomerated to be removed by filtration.

Neutralization is employed to adjust the pH of a waste stream to levels acceptable for discharge, usually to a pH between 6 and 9. The adjustment of pH is accomplished by the addition of acidic reagents or waste to alkaline streams, or by the addition of alkaline reagents or waste to acidic streams.

Precipitation is a widely-used, relatively low-cost chemical process which is commonly used to treat waste containing heavy metals. The chemical or physical nature of a stream is manipulated to reduce the solubility of undesirable solutes. The undesirable solutes then precipitate from the solution as a solid for removal by filtration or settling. Precipitation of an undesirable solute may be induced by:

- ° Addition of a chemical that will react with the solute to form an insoluble compound;

- ° Addition of a chemical that will shift the equilibrium of the system, reducing the solubility of the solute; or
- ° Change of the system temperature in the direction that reduces the solubility of the solute.

Precipitation is usually accomplished by chemical addition. Typical reagents are sodium hydroxide, sodium sulfide, lime, iron salts, iron sulfide, ferric sulfate, phosphate salts and alum.

Distillation can be used to remove most inorganic compounds from a liquid stream. The solution is boiled to drive off the liquid, leaving the inorganic substances as a residual solid or in a more concentrated solution.

Ion exchange is the reversible interchange of ions between an insoluble salt or resin - the ion exchange medium - and an ionic solution. In the process of ion exchange, unwanted ionic solutes, principally inorganic species, replace innocuous ions on the resin. Because ion exchange is for the most part reversible, the ion exchange medium can be regenerated. Overall, the ion exchange process produces two effluents: the purified liquid stream, and a periodic stream of spent regenerant, which contains elevated concentrations of the unwanted ionic solutes. The efficiency of ion exchange at removing metallic ions is generally very high.

Reverse osmosis removes contaminants from an aqueous stream by forcing the stream through a semi-permeable membrane. Under high pressure, in the range of 200 to 400 lb/in² (gauge), clean water passes through the membrane, leaving a more-concentrated waste behind. This more-concentrated waste must subsequently be treated or disposed of. The high applied pressures which act as the driving force for separation counteract the osmotic pressure developed by the dissolved contaminants - hence the name, reverse osmosis. Typically, semi-permeable membranes employed for reverse osmosis are impermeable to most inorganic species, as well as to fine particulates.

Reverse osmosis and ultrafiltration operate in a cross-flow configuration. As the waste stream flows through a membrane tube or a bundle of membrane tubes, purified water flows out through the membrane at right angles to the direction the waste is flowing. This differs from conventional filtration, where the waste passes directly through the filter medium and the contaminants are trapped on the upstream side. The cross-flow arrangements of reverse osmosis and ultrafiltration permit higher flow rates.

Methods which have been developed for treating ground water in-situ may be sensitive to such diverse factors as the characteristics of ground-water flow, the type of soil comprising the aquifer, the depth of the aquifer, and the nature of the contaminant.

A permeable treatment bed consists of a trench filled with a reactive permeable medium. Contaminated ground water or leachate that enters the bed reacts with the medium, producing a solid precipitate or a nonhazardous soluble compound. Contaminant removal may be enhanced by combination with chemical solution injection. In-situ physical and chemical treatments involve the direct application of a reactive material to the site to decontaminate the hazardous substances. An example of physical treatment is the placement of activated carbon in soil to adsorb organic materials. Chemical treatments may utilize neutralization, precipitation and/or oxidation-reduction reactions. The process of in-situ vitrification of site soil and fill would also operate to drive off ground water for collection by the off-gas treatment system. In-situ vitrification would thus decontaminate the groundwater, permitting it to be recharged or disposed of as nonhazardous.

Initial Screening

Since sedimentation is a common component in a water treatment system, this technology has been retained for further consideration.

Any liquid with filterable solids can be treated by filtration. At the Gould site, filtration could be applied as part of a complete water treatment process. Filtration could be used for pretreatment, particulate removal, polishing and dewatering; or to prevent the off-site transport of sediments during construction. Filtration has been retained for further consideration.

Neutralization is a preliminary step in water treatment which is generally applicable to aqueous leachate streams. Neutralization has been retained for further consideration.

Precipitation may be one stage in water treatment, and has therefore been retained for further consideration. However, the theoretical limits for removal of metal species from solution is often very low, and the removal achieved is usually one or two orders of magnitude less than theoretical limits. One factor that can reduce the removal of metals by precipitation is the action of complexants. Complexing agents in the waste may hold many species in solution, in spite of the action of precipitating agents.

Distillation is a technique which may be suitable for removing contaminants from surface water and ground water at the site. It has been retained for further consideration.

Ion exchange is an accepted method for removing dissolved inorganic salts from aqueous streams. This technology has been retained for further consideration.

Water treatment by reverse osmosis would achieve some of the remedial objectives listed in Section 2.1.1, eliminating contaminants from surface water and ground water and preventing their migration off site. Reverse osmosis has therefore been retained for further consideration.

Permeable treatment beds are applicable only to shallow aquifers, since a trench must be constructed to bedrock or an impermeable layer. At the Gould site, the underlying basalt does not form an impermeable layer, so that the use of a permeable treatment bed would not be technically feasible. Also, permeable treatment beds are often effective only for a short time, until the medium loses its reactive capacity or the bed becomes clogged with solids. The amount of time that a permeable treatment bed is effective can be increased by over-design, or by replacement of the medium. Use of a permeable treatment bed at the Gould site could require removal of the bed at some future date, both for replacement and for disposal of trapped contaminants. Finally, construction of the bed would result in uncontrolled drainage of contaminated water from the site. This technology will not be considered further.

The likely physical or chemical water treatments will be most successful when applied in separate facilities rather than in situ. Also, they will generally result in the site contaminants remaining in the soil, possibly in combination with other precipitates. There are, however, insufficient grounds for dismissing in-situ physical or chemical water treatment methods as infeasible or inappropriate at this time. These methods have therefore been retained for further consideration.

Any system chosen for treatment of water must account for the fact that both inorganic and organic constituents are present in the water. Cleanup for inorganics may not adequately remove toxic organics; conversely, organics may have to be removed by pretreatment to allow successful application of some inorganic treatment technologies.

As previously discussed, in-situ vitrification is still experimental, and constitutes an expensive technology. In-situ vitrification has already been eliminated from further consideration.

2.3.5 Disposal Options

Both the disposal of treated material on-site or off-site, and the disposal of untreated material off-site must meet the requirements of the various regulatory agencies. Materials requiring disposal might include fill materials, treated water, and residuals from various treatment operations.

2.3.5.1 Disposal of Fill Materials

2.3.5.1.1 On-Site Disposal

Description

Contaminated fill material could be disposed of in a regulated landfill on the site. A regulated landfill would require excavation of the contaminated material and installation of a double liner system, a leachate monitoring and collection system, and a surface cap. Evaluation of the site for a regulated landfill must consider potential risks posed by insufficient depth to ground water and the degree of naturally available ground-water protection should the liner system fail. Soil which has been treated and certified nonhazardous can be landfilled on-site without regard for ground-water protection.

Another means of on-site disposal of contaminated soil would be the construction of a vault. Vaults are often constructed below grade. A vault can be rectangular or circular in plan. A liner with leak detection and leachate collection systems is placed inside the vault. A low-permeability cap or membrane cover is placed over the top of the vault to prevent surface infiltration. The site is then backfilled to grade and surfaced to control run-on, runoff and drainage.

A vault constructed above-grade would be similar to a below-grade vault. An above-grade vault would be formed by lined berms. The volume of contaminated material at the site is such that it cannot all be contained in a vault occupying half of the site, although portions of the fill such as the soil, sediment and matte could be so contained.

Both an on-site landfill and an on-site disposal vault for disposal of untreated materials would require long-term ground-water and leak detection monitoring.

Initial Screening

A hazardous waste landfill should be placed above the ground-water table, to prevent uplifting of the liner leading to rupture of the liner. The RI indicated that the ground water can rise to within four feet of grade at times. The shallow depth of ground water at the site precludes landfilling contaminated materials there, and construction of an on-site landfill will not be considered further. Construction of a vault above the water table is possible, however, and this option has been retained for further consideration. Landfilling of treated materials has been retained for further consideration, as well.

2.3.5.1.2 Off-Site Disposal

Description

Contaminated soil that has been treated and certified nonhazardous can be disposed of at any landfill. Contaminated soil that has not been treated must be disposed of in an appropriate treatment, storage and disposal (TSD) facility.

Initial Screening

Off-site disposal of hazardous materials is becoming increasingly difficult because of increasingly restrictive regulation. In particular, SARA strongly discourages off-site disposal without treatment. The nearest permitted TSD facility is located in Arlington, Oregon, at roughly 150 miles from the Gould site. While off-site disposal is not favored, it is feasible, and has been retained for further consideration.

2.3.5.1.3 Disposal of Treated Water and Sludge

Description

Technologies for placing treated water into the earth are readily available. Injection wells pump the water directly into an aquifer. Subsurface drains and infiltration basins rely on percolation through the soil, and must be located on a permeable stratum. Trenches recharge an aquifer directly.

Treated water could be discharged to the East Doane Lake remnant, with any excess being allowed to overflow to the Willamette River; or it could be discharged to the Willamette River directly.

Treated water could be discharged to a City of Portland sanitary sewer, provided such discharge has been approved by the city. There is a sanitary sewer located on the site which can accept a limited effluent flow from the Gould site. No negotiations have been held with the City of Portland to confirm actual permit requirements.

Evaporation ponds can be constructed to reduce the volume of liquid waste, or existing bodies of surface water can be maintained to act as evaporation ponds. This method depends on the local evaporation rate exceeding the precipitation rate.

Sludge is a product of both soil and water treatment. Sludge from treatment of site soil and water may be contaminated with lead, cadmium and arsenic.

Initial Screening

The level of the ground-water table under the Gould site renders subsurface drains and infiltration basins impractical. Trenches are not suitable due to the potential for cross-contamination of treated water by untreated water. These methods will not be considered further. Injection wells have been retained for further consideration.

Effluent discharge requirements must be met for releasing treated water to the Willamette River. This is a feasible method for disposing of treated water, and will be investigated further.

Requirements of the City of Portland must be met prior to discharge to a city sewer. A key concern will be the capacity of the sewer to accept the additional effluent. This is a feasible method for disposing of treated water.

Since precipitation in the Portland area exceeds evaporation, disposal of treated water by evaporation is not feasible. In addition, the evaporation of water contained in a basin or pond may deposit contaminated residues as sediments. These sediments would then be available for wind scouring, and could contribute to airborne pollution. This technology has been eliminated from further consideration.

Off-site disposal is well suited to disposal of the small volumes of sludge anticipated from soil and water treatment at the site. This approach has been retained for further consideration.

2.3.6 Institutional Controls

Five institutional controls have been considered at the Gould site: well permit restrictions, site access restrictions, land use restrictions, deed restrictions, and restrictions on sale of the property.

2.3.6.1 Well Permit Restrictions

Description

The Oregon Department of Environmental Quality (DEQ) has jurisdiction over all well permits. Therefore, the DEQ has the authority to deny well permits based on public health concerns. Users of potable water from wells affected by site contaminants could be required to use city water.

Initial Screening

Well permit restrictions can be implemented with minimal cost to the user because of the availability of piped potable water from the City of Portland. The DEQ has been asked to comment on the ability of agencies to limit the placement of wells in the shallow aquifer systems. Because site contaminants are located at shallow depths, well permit restrictions for this aquifer would be effective in protecting the public from water affected by site contaminants. Therefore, this control will be considered further.

2.3.6.2 Site Access Restrictions

Description

Two restrictions on access may be applied to the site to limit contact with contaminated materials: restriction of public access, and restriction of occupational use. The physical requirements of these restrictions would be fences, gates, signs, and possibly alarm or other detection systems.

Initial Screening

These restrictions are feasible controls, and have been retained for further consideration.

2.3.6.3 Land Use Restrictions

Description

Land use restrictions could be imposed by the City of Portland to limit future uses of the site to those appropriate to its status.

Initial Screening

Land use restrictions are feasible controls, and have been retained for further consideration.

2.3.6.4 Deed Restrictions

Description

Under recently enacted legislation, the current owner of the site, Gould Inc., may be required to place certain use restrictions in the deed to the site. Such restrictions would apply to the extent contamination of the site was not mitigated.

Initial Screening

Deed restrictions are effective controls. Future site owners would have the ability to fully review site history prior to sale. These restrictions have been retained for further consideration.

2.3.6.5 Sale Restrictions

Description

Among the rights a property owner possesses, in addition to the right to impose voluntary deed restrictions, is the right to legally bind the owner, his heirs, and his successors to a commitment that the property will not be sold in perpetuity. As with deed restrictions, such a legal commitment can consist of a notation on the property deed, or on some other instrument which is normally examined during a title search.

Initial Screening

Restrictions on sale of the property could serve as effective institutional controls. These restrictions have been retained for further consideration.

2.4 SUMMARY OF REMEDIAL TECHNOLOGIES

Table 2.4-1 presents the results of the above screening of technologies. The table identifies those technologies that have been retained for incorporation into remedial alternatives. The table also identifies those technologies that have been determined to be infeasible or inapplicable, and have therefore been eliminated from further consideration.

TABLE 2.4-1

REMEDIAL ACTION TECHNOLOGIES APPLICABLE TO THE GOULD SITE

Page 1 of 11

	RETAINED	ELIMINATED
No Action	X	
Monitoring		
Air Quality Monitoring	X	
Monitoring Wells	X	
Monitoring of Surface Water	X	
Control of Airborne Contaminant Migration		
Surface Treatment		
Paving or Capping		
Asphalt	X	
Portland Cement	X	
Layered Cover System	X	
Fixation/Solidification		
Asphalt	X	
Portland Cement	X	
Lime Treatment	X	
Pozzolanic Cementation	X	
Proprietary Technologies		
Weston Services, Inc.	X	
Silicate Technologies, Inc.	X	
Revegetation	X	
Surface Soil Treatment/Disposal		
Soil Removal for Treatment/Disposal	X	
On-Site Treatment		
Portland Cement	X	
Lime Treatment	X	
Thermoplastic Binding		X
Pozzolanic Cementation	X	
Proprietary Technologies		
Weston Services, Inc.	X	
Silicate Technologies	X	
LOPAT Enterprises, Inc.	X	

TABLE 2.4-1 (Continued)

Page 2 of 11

	RETAINED	ELIMINATED
Soil Washing/Leaching		
Precipitation		X
Acid or Base Leaching	X	
Chelation		X
In-Situ Treatment		
Solution Mining		X
Weston Services, Inc.	X	
Silicate Technologies, Inc.	X	
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	
Battery Casings Treatment/Disposal		
Casings Removal for Treatment/Disposal	X	
Recycle of Casing Materials		
Component Separation		
MA Industries, Inc.	X	
Polycycle Industries	X	
Cal West	X	
Heavy Media Separation		X
Materials Recycling		
Lead	X	
Lead Oxide	X	
Plastic	X	
Ebonite	X	
Incineration of Casing Materials	X	
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	

TABLE 2.4-1 (Continued)

Page 3 of 11

	RETAINED	ELIMINATED
Installation of Wind Fences or Screens		X
Control of Surface Contamination		
Surface Treatment		
Paving or Capping		
Asphalt	X	
Portland Cement	X	
Layered Cover System	X	
Fixation/Solidification		
Asphalt	X	
Portland Cement	X	
Lime Treatment	X	
Pozzolanic Cementation	X	
Proprietary Technologies		
Weston Services, Inc.	X	
Silicate Technologies, Inc.	X	
. Revegetation	X	
Surface Soil Treatment/Disposal		
Soil Removal for Treatment/Disposal	X	
On-Site Treatment		
Portland Cement	X	
Lime Treatment	X	
Thermoplastic Binding		X
Pozzolanic Cementation	X	
Proprietary Technologies		
Weston Services, Inc.	X	
Silicate Technologies	X	
LOPAT Enterprises, Inc.	X	
Soil Washing/Leaching		
Precipitation		X
Acid or Base Leaching	X	
Chelation		X
In-Situ Treatment		
Solution Mining		X
Weston Services, Inc.	X	
Silicate Technologies, Inc.	X	

TABLE 2.4-1 (Continued)

Page 4 of 11

	RETAINED	ELIMINATED
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	
Battery Casings Treatment/Disposal		
Casings Removal for Treatment/Disposal	X	
Recycle of Casing Materials		
Component Separation		
MA Industries, Inc.	X	
Polycycle Industries	X	
Cal West	X	
Heavy Media Separation		X
Materials Recycling		
Lead	X	
Lead Oxide	X	
Plastic	X	
Ebonite	X	
Incineration of Casing Materials	X	
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	
Control of Subsurface Contamination		
Subsurface Soil Treatment/Disposal		
Soil Removal for Treatment/Disposal	X	

TABLE 2.4-1 (Continued)

Page 5 of 11

	RETAINED	ELIMINATED
On-Site Treatment		
Portland Cement	X	
Lime Treatment	X	
Thermoplastic Binding		X
Pozzolanic Cementation	X	
Proprietary Technologies		
Weston Services, Inc.	X	
Silicate Technologies	X	
LOPAT Enterprises, Inc.	X	
Soil Washing/Leaching		
Precipitation		X
Acid or Base Leaching	X	
Chelation		X
In-Situ Treatment		
Solution Mining		X
Weston Services, Inc.	X	
Silicate Technologies, Inc.	X	
In-Situ Vitrification		X
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	
Battery Casings Treatment/Disposal		
Casings Removal for Treatment/Disposal	X	
Recycle of Casing Materials		
Component Separation		
MA Industries, Inc.	X	
Polycycle Industries	X	
Cal West	X	
Heavy Media Separation		X
Materials Recycling		
Lead	X	
Lead Oxide	X	
Plastic	X	
Ebonite	X	
Incineration of Casing Materials	X	

TABLE 2.4-1 (Continued)

Page 6 of 11

	RETAINED	ELIMINATED
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	
Matte Treatment/Disposal		
Matte Removal for Treatment/Disposal	X	
On-Site Treatment		
Portland Cement	X	
Lime Treatment	X	
Thermoplastic Binding		X
Pozzolanic Cementation	X	
Proprietary Technologies		
Weston Services, Inc.	X	
Silicate Technologies	X	
LOPAT Enterprises, Inc.	X	
Soil Washing/Leaching		
Precipitation		X
Acid or Base Leaching	X	
Chelation		X
In-Situ Treatment		
Solution Mining		X
Weston Services, Inc.	X	
Silicate Technologies, Inc.	X	
In-Situ Vitrification		X
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	

TABLE 2.4-1 (Continued)

Page 7 of 11

	RETAINED	ELIMINATED
Control of Contaminant Migration in Surface Water		
Surface Treatment		
Paving or Capping		
Asphalt	X	
Portland Cement	X	
Layered Cover System	X	
Fixation/Solidification		
Asphalt	X	
Portland Cement	X	
Lime Treatment	X	
Pozzolanic Cementation	X	
Proprietary Technologies		
Weston Services, Inc.	X	
Silicate Technologies, Inc.	X	
Revegetation	X	
Surface Water Treatment		
Sedimentation	X	
Filtration	X	
Neutralization	X	
Precipitation	X	
Distillation	X	
Ion exchange	X	
Reverse Osmosis	X	
Sediment Treatment/Disposal		
Sediment Removal for Treatment/Disposal	X	
On-Site Treatment		
Portland Cement	X	
Lime Treatment	X	
Thermoplastic Binding		X
Pozzolanic Cementation	X	
Proprietary Technologies		
Weston Services, Inc.	X	
Silicate Technologies	X	
LOPAT Enterprises, Inc.	X	
Soil Washing/Leaching		
Solution Mining		X
Precipitation		X
Acid or Base Leaching	X	
Chelation		X

TABLE 2.4-1 (Continued)

Page 8 of 11

	RETAINED	ELIMINATED
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	
Battery Casings Treatment/Disposal		
Casings Removal for Treatment/Disposal	X	
Recycle of Casing Materials		
Component Separation		
MA Industries, Inc.	X	
Polycycle Industries	X	
Cal West	X	
Heavy Media Separation		X
Materials Recycling		
Lead	X	
Lead Oxide	X	
Plastic	X	
Ebonite	X	
Incineration of Casing Materials	X	
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	
Control of Contaminant Migration in Ground Water		
Surface Treatment		
Paving or Capping		
Asphalt	X	
Portland Cement	X	
Layered Cover System	X	

TABLE 3.4-1 Continued)

Page 9 of 11

	RETAINED	ELIMINATED
Fixation/Solidification		
Asphalt	X	
Portland Cement	X	
Lime Treatment	X	
Pozzolanic Cementation	X	
Proprietary Technologies		
Weston Services, Inc.	X	
Silicate Technologies, Inc.	X	
Revegetation	X	
Leachate Plume Barriers		
Slurry Walls	X	
Grout Curtains		X
Sheet Pile Cutoff Walls		X
Block Displacement Method		X
Injection Recharge	X	
Groundwater Treatment/Disposal		
Groundwater Removal for Treatment		
Pumping Systems		
Well Points	X	
Suction Wells	X	
Ejector Wells		X
Subsurface Drainage Systems		
Subsurface Drains		X
Trenches		X
Ejector Wells		X
Groundwater Treatment		
Sedimentation	X	
Filtration	X	
Neutralization	X	
Precipitation	X	
Distillation	X	
Ion exchange	X	
Reverse Osmosis	X	
In-Situ Treatment		
Permeable Treatment Beds		X
In-Situ Physical/Chemical Treatment	X	
In-Situ Vitrification		X

TABLE 2.4-1 (Continued)

Page 10 of 11

	RETAINED	ELIMINATED
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	
Disposal of Treated Materials		
Disposal of Treated Soils		
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	
Disposal of Treated Sediments		
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	
Disposal of Battery Casing Fragments		
Component Separation		
MA Industries, Inc.	X	
Polycycle Industries	X	
Cal West	X	
Heavy Media Separation		X
Materials Recycling		
Lead	X	
Lead Oxide	X	
Plastic	X	
Ebonite	X	

TABLE 2.4-1 (Concluded)

Page 11 of 11

	RETAINED	ELIMINATED
Incineration of Casing Materials	X	
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	
Disposal of Treated Matte		
On-Site Disposal		
Landfill		
Treated Material	X	
Untreated Material		X
Vault	X	
Off-Site Disposal	X	
Disposal of Treated Water		
Recharge of Treated Water		
Well Points	X	
Trenches		X
Discharge to Water Body		
Discharge to Willamette	X	
Discharge to East Doane Lake Remnant	X	
Discharge to Sewer	X	
Evaporation		X
Institutional Controls		
Well Permit Restrictions	X	
Site Access Restrictions	X	
Land Use Restrictions	X	
Deed Restrictions	X	
Sale Restrictions	X	

3.0 DEVELOPMENT AND SCREENING OF THE PRELIMINARY ALTERNATIVES

Section 2.0 summarized the process used to determine the technologies appropriate for remedying hazards at the Gould site. First, technical criteria were developed. Then, general response actions were identified. Next, technologies available for performing each of the general response actions were investigated. Finally, infeasible or inapplicable technologies were eliminated from further consideration.

Technologies which were not eliminated by the technology screening process are combined in this section into remedial action alternatives. Remedial action alternatives are packages comprised of the applicable technologies. The alternatives are intended to address the important site problems and the significant pathways of contaminant migration that were found during the RI. In this section, preliminary remedial action alternatives for the Gould site are developed and evaluated. During the evaluation, the preliminary alternatives are screened. Preliminary alternatives are eliminated from further consideration, if they 1) do not adequately protect the public or the environment from site contaminants; 2) have significant side-effects; or 3) are an order of magnitude higher in cost than other alternatives, without providing greater benefits, protection or reliability.

The screening of the preliminary alternatives to eliminate those which are not protective or are overly expensive produces a small group of final candidate remedial action alternatives. The final alternatives are evaluated in detail to assess their effectiveness, implementability and cost. For each of the final remedial action alternatives, the following information is developed:

- ° Technical background
- ° Health information, presented in the Endangerment Assessment
- ° Environmental effects
- ° Extent of compliance with environmental regulations
- ° Information about possible effects on neighboring communities
- ° Information pertinent to off-site disposal
- ° Present worth of total costs
- ° Institutional and site-specific factors.

The final remedial action alternatives are fully described in Section 4.0. The detailed evaluation of the final remedial action alternatives is discussed in Section 6.0.

3.1 DEVELOPMENT OF PRELIMINARY REMEDIAL OPTIONS

The general response actions outlined in Section 2.2 address hazards from a number of sources at the site. Contaminants at the site are dispersed over the surface, in the fill and in the soil surrounding the fill, in sediments on the bottom of the East Doane Lake remnant, and in surface water and ground water. Hazards from the contaminants may be reduced by controlling any or all of the sources.

A large number of preliminary remedial action alternatives may be constructed from technologies associated with the general response actions. Each of the general response actions listed in Table 2.1 constitutes a group of potential remedial alternatives, since 1) each action may accomplish one or more of the site remedial objectives, and 2) each of the associated remedial technologies retained through the technology screening process may achieve the general response action. Thus, under the heading of Control of Airborne Contaminant Migration, potential remedial alternatives can be constructed which employ surface treatment, or surface soil treatment, or battery casing treatment/disposal, as their sole remedial measure. In addition, any assemblage of the general response actions constitutes a group of potential remedial alternatives, since any combination of the associated technologies may achieve the objectives of the assembled general response actions.

For the Gould site, the number of alternatives that can be developed by simply combining technologies is especially large. The large number of possible alternatives results from 1) the diversity of contaminated materials at the site; 2) the presence on-site of a surface water body, the East Doane Lake remnant, which collects drainage from the site and adjacent properties and discharges directly into the Willamette River; and 3) the possibility of recovering and recycling materials from the battery casing fragments, thereby reducing the quantity of hazardous waste that must be otherwise treated or disposed of. The first task in developing preliminary remedial action alternatives is to reduce this large number of possible combinations to a workable number.

The total number of alternatives formed by combining technologies is reduced substantially when similar treatments are applied to similar hazards. For example, an alternative which includes treatment of both soil and sediment and which stipulates treatment of soil by fixation/stabilization should require treatment of sediment by fixation/stabilization, as well. Limiting, as far as possible, the number of treatments applied to the site reflects good engineering practice, preventing the application of possibly incompatible methods and procedures; and will in general be the most cost-effective approach.

The expediency of applying similar treatments to similar hazards supports joining the treatment technologies for several of the contaminant sources together. Technologies which have been retained for treating surface soil, subsurface soil and matte are in large part identical and are expected to perform similarly, so that they may be considered jointly. Realistically, it would be difficult to separate these materials in order to apply different treatments to them.

Even after incompatible combinations of the technologies are eliminated and similar treatments are grouped, however, the number of possible combinations of technologies into remedial action alternatives for application at the site is too large and unwieldy for the screening process.

In order to effectively screen the remedial alternatives, options which address the site fill materials are evaluated first, without consideration for surface treatment, surface water treatment or ground-water treatment. Surface treatment, surface water treatment and ground-water treatment address several of the identified remedial objectives, and are important components of the general response action categories. The method of surface treatment, though, will be largely determined by the method of treating the fill. If, for example, the fill is disposed of in an on-site RCRA-approved vault, the only compatible surface treatments consist of paving or capping. If, on the other hand, the fill is disposed of by fixation/stabilization, the only compatible surface treatments consist of fixation/stabilization. Alternatives which are distinct from one another due solely to the method of surface treatment will arise only if the fill is disposed of on-site. In those instances, at most three distinct alternatives will arise, since only three technologies for surface treatment were retained through the screening process.

The methods chosen for treating surface water and ground water, on the other hand, will be somewhat independent of the method for treating the fill. Certainly, the complete removal or treatment of site contaminants will make long-term treatment of surface water and ground water unnecessary; and the control of contaminant migration using barriers to ground-water flow may render some fill treatments unneeded. However, any interaction of fill treatment with water treatment, such as the two cited, will be apparent when the water treatment technologies are combined with the remedial action options developed for the fill.

The second task in developing preliminary remedial action alternatives for the site, then, is the development of remedial action

options for the fill materials. Table 3.1-1 presents the remedial technologies applicable to the site fill. These technologies are combined into remedial action options in Table 3.1-2.

In Table 3.1-2, the preliminary remedial options have been arbitrarily divided into three categories. These categories are based on how the battery casing fragments are treated. The only purpose of these three categories is to simplify the comparison of alternatives in Section 3.2.

In the process of combining the applicable technologies for the fill into preliminary remedial options, several refinements of the technologies and the options have been introduced. Table 3.1-2 therefore represents more than a simple combination of the applicable technologies for treating the fill. The refinements include additional categories of battery casing technologies, as follows:

- ° On-site lead oxide treatment and disposal;
- ° Off-site lead oxide disposal;
- ° Ebonite incineration; and
- ° Surface pile removal and disposal.

The first two categories have been included to provide alternatives to the recycling of lead oxide, in case separation of lead oxide from the battery casing fragments proves less than adequate. Recycling of lead oxide may require a degree of separation greater than the separation technologies can provide. If lead oxide that is sufficiently pure cannot be reclaimed, it may be disposed of using the technology that is applied to the soil and matte. The third category has been included to provide an alternative to ebonite recycling, in case recycling proves infeasible. The last category is a partial treatment aimed at reducing the long-term hazards of airborne contaminant dispersal at the site, while minimizing the generation of fugitive dust that may occur due to complete excavation of the battery casing fragments.

Certain of the possible options have not been included in Table 3.1-2. While options involving treatment of sediment as their major remedial method are included, options involving either treatment of battery casings or treatment of surface and subsurface soil and matte as their major remedial method are not. There are two reasons for treating sediments without treating the remainder of the site fill. First, contaminants in the sediments may dissolve into the East Doane Lake remnant and be transported directly to the Willamette River. Treatment of sediments therefore restricts a major pathway for contaminant migration

TABLE 3.1-1

REMEDIAL TECHNOLOGIES APPLICABLE TO THE SITE FILL

A. Battery Casings Treatment/Disposal

1. Casings Removal for Treatment/Disposal
2. Recycle of Casing Materials
 - a. Component Separation
 - (1) MA Industries, Inc.
 - (2) Polycycle Industries
 - (3) Cal West
 - b. Materials Recycling
 - (1) Lead
 - (2) Lead Oxide
 - (3) Plastic
 - (4) Ebonite
3. Incineration of Casing Materials
4. On-Site Disposal Vault
5. Off-Site Disposal

B. Surface and Subsurface Soil and Matte Treatment/Disposal

1. Soil Removal for Treatment/Disposal
2. On-Site Treatment
 - a. Portland Cement
 - b. Lime Treatment
 - c. Pozzolanic Cementation
 - d. Proprietary Technologies
 - (1) Weston Services, Inc.
 - (2) Silicate Technologies
 - (3) LOPAT Enterprises, Inc.
 - e. Acid or Base Leaching
 - f. In-Situ Treatment
 - (1) Weston Services, Inc.
 - (2) Silicate Technologies, Inc.
3. On-Site Disposal
 - a. Landfill of Treated Material
 - b. Vault
4. Off-Site Disposal

C. Sediment Treatment/Disposal

1. Sediment Removal for Treatment/Disposal
2. On-Site Treatment
 - a. Portland Cement
 - b. Lime Treatment
 - c. Pozzolanic Cementation
 - d. Proprietary Technologies
 - (1) Weston Services, Inc.
 - (2) Silicate Technologies
 - (3) LOPAT Enterprises, Inc.
 - e. Acid of Base Leaching
3. On-Site Disposal
 - a. Landfill of Treated Material
 - b. Vault
4. Off-Site Disposal

TABLE 3.1-2 Combination of the Applicable Technologies into Preliminary Remedial Options

Remedial Category Specific Feature	<div> <div>Options Involving Minimal Treatment of Battery Casings</div> <div>Options Involving Treatment of Battery Casings as a Principal Element</div> <div>Options Involving Disposal or Incineration of Battery Casings</div> </div>																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Battery Casings																														
Casings Remove/Treat/Recycle																														
Component Separation									X	X	X	X	X	X	X	X	X	X	X	X										
PbO ₂ On-Site Treat/Dispose										X	X		X	X		X	X													
PbO/Soil Off-Site Disposal																			X	X										
Monite Incineration											X			X			X		X											
Casings Remove/Dispose																														
Surface Pile Remove/Dispose		X				X	X	X																						
On-Site Disposal																					X									
Off-Site Disposal																						X								
Incineration																								X			X	X	X	X
Surface & Subsurface Soil & Matte																														
Soil/Matte Remove/Treat/Replace																														
Fixation/Stabilization									X	X	X										X	X					X			
Chemical Treatment												X	X	X									X	X				X		
Soil/Matte Remove/Dispose																														
On-Site Disposal															X	X	X								X				X	
Off-Site Disposal																		X	X	X						X				X
Sediments																														
Sediment Remove/Treat/Replace																														
Fixation/Stabilization																					X	X					X			
Chemical Treatment												X	X	X									X	X				X		
Sediment Remove/Dispose																														
On-Site Disposal															X	X	X								X				X	
Off-Site Disposal						X		X										X	X	X						X				X

off-site. Second, the sediments are saturated, so that their excavation should generate little fugitive dust. Excavation of unsaturated fill, by contrast, may generate significant amounts of fugitive dust. Treating the battery casings, the surface or subsurface soil or the matte without treating the sediments, on the other hand, does not address a major remedial objective, since it does not control the migration of contaminants in surface water. In addition, removal of battery casings for treatment and disposal will almost certainly disturb the sediments in the East Doane Lake remnant, since the battery casing fragments form the southwest border of the East Doane Lake remnant.

The preliminary remedial options identified in Table 3.1-2 are listed in Table 3.1-3. The preliminary options constitute a range of approaches from no action, to treatment of the majority of the fill materials, to off-site disposal of the fill materials. As indicated in Table 3.1-3, Option 1 is the No-Action Alternative. Option 25 is an on-site disposal option and Option 26 is an off-site disposal option.

Beginning with the No-Action Alternative, each preliminary option can be thought of in turn as a more sophisticated strategy, addressing more of the site hazards and implementing more of the general response actions than its predecessor. When the options for the Gould site are organized in this manner, according to their degree of sophistication, the general response actions with the greatest effect on health and the environment are listed first. The most likely exposure pathway for site contaminants is through airborne dispersal, and this is addressed in part by surface pile removal (the control of airborne contamination is largely the function of surface treatment, which is considered separately). The next most likely exposure pathway is through migration in surface water, which is addressed in part by sediment removal, treatment and disposal. The next most likely pathways are through direct contaminant ingestion and through contaminant migration in ground water, which are addressed in part by fill removal, treatment and disposal.

Options for treating surface water and ground water are presented in Table 3.1-4. This table was developed in the same manner as Table 3.1-2, which represents the options for treating the fill. Option NW represents no water treatment, and corresponds to the No-Action Alternative. Options SW1, SW2, and SW3 implement surface water treatments only, while Options SG1, SG2, SG3, SG4, SG5 and SG6 implement surface water and ground-water treatments. As in the earlier process of combining applicable technologies for the fill, certain refinements of the technologies and the options for surface water have been introduced

TABLE 3.1-3

PRELIMINARY REMEDIAL OPTIONS

Page 1 of 3

OPTION 1

No-Action Alternative

OPTION 2

Removal and Disposal of Surface Piles of Battery Casings

OPTION 3

Fixation/Stabilization of Sediments

OPTION 4

Chemical Treatment of Sediments

OPTION 5

Off-Site Disposal of Sediments

OPTION 6

Removal and Disposal of Surface Piles of Battery Casings
Fixation/Stabilization of Sediments

OPTION 7

Removal and Disposal of Surface Piles of Battery Casings
Chemical Treatment of Sediments

OPTION 8

Removal and Disposal of Surface Piles of Battery Casings
Off-Site Disposal of Sediments

OPTION 9

Battery Casings Component Separation
Fixation/Stabilization of Surface Soil/Subsurface
Soil/Sediments/Matte

OPTION 10

Battery Casings Component Separation
Fixation/Stabilization of Surface Soil/Subsurface
Soil/Sediments/Matte/Lead Oxide & Soil Mixture

OPTION 11

Battery Casings Component Separation
Incineration of Ebonite
Fixation/Stabilization of Surface Soil/Subsurface
Soil/Sediments/Matte/Lead Oxide & Soil Mixture

OPTION 12

Chemical Treatment of Surface Soil/Subsurface
Soil/Sediments/Matte
Battery Casings Component Separation

OPTION 13

Battery Casings Component Separation
Chemical Treatment of Surface Soil/Subsurface
Soil/Sediments/Matte/Lead Oxide & Soil Mixture

OPTION 14

Battery Casings Component Separation
Incineration of Ebonite
Chemical Treatment of Surface Soil/Subsurface
Soil/Sediments/Matte/Lead Oxide & Soil Mixture

OPTION 15

Battery Casings Component Separation
On-Site Disposal of Surface Soil/Subsurface
Soil/Sediments/Matte

OPTION 16

Battery Casings Component Separation
On-Site Disposal of Surface Soil/Subsurface
Soil/Sediments/Matte/Lead Oxide & Soil Mixture

OPTION 17

Battery Casings Component Separation
Incineration of Ebonite
On-Site Disposal of Surface Soil/Subsurface
Soil/Sediments/Matte/Lead Oxide & Soil Mixture

OPTION 18

Battery Casings Component Separation
Off-Site Disposal of Surface Soil/Subsurface
Soil/Sediments/Matte

OPTION 19

Battery Casings Component Separation
Off-Site Disposal of Surface Soil/Subsurface
Soil/Sediments/Matte/Lead Oxide & Soil Mixture

OPTION 20

Battery Casings Component Separation
Incineration of Ebonite
Off-Site Disposal of Surface Soil/Subsurface
Soil/Sediments/Matte/Lead Oxide & Soil Mixture

OPTION 21

Battery Casings On-Site Disposal
Fixation/Stabilization of Surface Soil/Subsurface
Soil/Sediments/Matte

TABLE 3.1-3 (Concluded)

OPTION 22

Battery Casings Off-Site Disposal
Fixation/Stabilization of Surface Soil/Subsurface
Soil/Sediments/Matte

OPTION 23

Battery Casings On-Site Disposal
Chemical Treatment of Surface Soil/Subsurface
Soil/Sediments/Matte

OPTION 24

Battery Casings Off-Site Disposal
Chemical Treatment of Surface Soil/Subsurface
Soil/Sediments/Matte

OPTION 25

On-Site Disposal Option

OPTION 26

Off-Site Disposal Option

OPTION 27

Battery Casings Incineration
Fixation/Stabilization of Surface Soil/Subsurface
Soil/Sediments/Matte

OPTION 28

Battery Casings Incineration
Chemical Treatment of Surface Soil/Subsurface
Soil/Sediments/Matte

OPTION 29

Battery Casings Incineration
On-Site Disposal of Surface Soil/Subsurface
Soil/Sediments/Matte

OPTION 30

Battery Casings Incineration
Off-Site Disposal of Surface Soil/Subsurface
Soil/Sediments/Matte

TABLE 3.1-4

REMEDIAL OPTIONS FOR SURFACE WATER AND GROUND WATER

Remedial Category Specific Feature	NW	SW1	SW2	SW3	SG1	SG2	SG3	SG4	SG5	SG6
Surface Water Treatment										
Surface Water Isolation		X			X					
Surface Water Remove/ Treat/Replace			X			X		X		
Surface Water Remove/ Treat/Dispose				X			X		X	X
Groundwater Treatment										
Leachate Plume Barrier					X					X
Groundwater Remove/ Treat/Replace						X				
Groundwater Remove/ Treat/Dispose							X			
Groundwater In-Situ Treatment								X	X	

into Table 3.1-4. These refinements include an additional category of surface water treatment, which is surface water isolation. This additional category is a partial treatment intended to reduce the off-site hazards of contaminant dispersal through surface water, while minimizing the mechanical mixing of contaminants with surface water and ground water that may accompany excavation of lake sediments.

3.2 SCREENING OF THE PRELIMINARY REMEDIAL OPTIONS

In this section, the preliminary remedial action options for the site fill are evaluated for their effectiveness, implementability and cost. As part of the evaluation process, the preliminary options are screened to reduce them to a small group of final candidate remedial options. Preliminary options are eliminated from further consideration, if they 1) do not adequately protect the public or the environment from site contaminants; 2) have significant side-effects; or 3) are an order of magnitude higher in cost than other alternatives, without providing greater benefits, protection or reliability. The small group of final remedial options retained through the screening process is subsequently developed into the selected candidate alternatives.

3.2.1 Remedial Response Criteria

Evaluation of remedial alternatives for the Gould site includes a discussion of the degree to which each of the alternatives achieves applicable or relevant and appropriate requirements (ARARs). Applicable standards are those that would legally apply if the action was not being taken under CERCLA. Relevant and appropriate standards are those designed to apply to circumstances similar to those encountered at CERCLA sites in which their application would be appropriate. Under SARA, these ARARs are used in the evaluation process as primary remediation goals.

The requirements of SARA play an important role in evaluating alternatives for an onsite remedial action. SARA requires the selected remedy to attain ARARs unless such requirements are waived. For the Gould site, this requirement applies to Federal requirements of the Safe Drinking Water Act, the Clean Air Act, and the Solid Waste Disposal Act. SARA stipulates that remedial actions are required to at least attain MCLs and water quality criteria under the Clean Water Act, where such a requirement is relevant and appropriate under the circumstances.

SARA addresses state requirements as well. Remedial actions must attain any promulgated State requirement under a State environmental or

facility siting law that is more stringent than any Federal requirement. SARA does not require remedial actions to attain State requirements that are proposed but not promulgated.

Under SARA, EPA may grant a waiver from the requirement to attain ARARs for privately financed remedial actions under any of the following conditions:

- ° The remedial action is an interim measure where the final remedy will attain the ARAR upon completion;
- ° Compliance with an ARAR will result in greater risk to human health and the environment than other options;
- ° Compliance is technically impracticable;
- ° The standard of performance under an alternative remedial action is equivalent to the ARAR; and
- ° For State requirements, the State has not consistently applied the State requirement in similar circumstances.

In evaluating alternatives, it is first necessary to determine which ARARs exist for the site and contaminants. State standards, criteria, and other guidance should also be considered. The following pages identify requirements that are pertinent to the Gould site. A table was provided by EPA as an internal draft policy response to SARA requirements. The table, which lists ARARs according to the three categories of chemical-specific ARARs, location-specific probable ARARs, and action-specific probable ARARs, was reviewed during evaluation of remedial action alternatives for the Gould site. A summary of chemical specific ARARs deemed applicable to the Gould site is contained in Table 3.2-1.

The ARARs summarized in Table 3.2-1 contain several sets of numbers that could be applied to the Willamette: (1) the MCL; (2) Ambient Water Quality Criteria for Human Health; (3) Ambient Water Quality Criteria for Freshwater Aquatic Organisms; or (4) Oregon Water Quality Standards. For discussion of effects of site contaminants on the Willamette, the appropriate standard is the Oregon Water Quality Standard, which for lead is the same as the MCL or the Ambient Water Quality Criteria for Human Health. The Ambient Water Quality Criteria for Freshwater Aquatic Organisms are deemed inapplicable because a promulgated standard under State law is a more appropriate and relevant requirement than a criterion, or guideline, concentration.

TABLE 3.2-1

CHEMICAL-SPECIFIC ARARS FOR THE GOULD SITE

Contaminants	MCL ¹ (mg/l)	NAAQS ² (ug/m ³)	Ambient Water Quality Criteria ³			Oregon ⁵ Water Quality Standards (mg/l)
			Human Health (mg/l)	Freshwater Aquatic Life ⁴		
				Acute (mg/l)	Chronic (mg/l)	
Arsenic	0.05 0.05	-- --	(6) (6)	0.36	0.19	0.01
Cadmium	0.01	--	0.01	0.0018	0.00066	0.003
Chromium (III)	0.05 ⁷	--	170	1.7	0.21	0.02 ⁷
Chromium (VI)	0.05 ⁷	--	0.05	0.016	0.011	0.02 ⁷
Lead	0.05	1.5 (90 day)	0.05	0.034	0.0013	0.05
Zinc	--	--	5.0	0.18	0.047	0.01

Notes:

1 Maximum Contaminant Level.

2 National Ambient Air Quality Standards.

3 Source: EPA: Quality Criteria for Water (1986) EPA 440/5-86-001.

4 Where applicable, numbers assume a hardness of 50 mg/l as CaCO₃ for the Willamette River.

5 Source: Oregon Administrative Rules (OAR) 340-41-445(2)(o).

6 See Endangerment Assessment.

7 Standard applies to total chromium.

Other considerations apply to the Ambient Water Quality Criteria for Freshwater Aquatic Organisms, which have informational value for discussions of aquatic toxicity. Mitigating factors relevant to East Doane Lake discharges are present. The chronic criterion of 0.0013 mg/l and acute criterion of 0.034 mg/l are for aquatic organism exposure periods of 4 days and 1 hour, respectively. No data have been collected to determine the actual concentration of lead in the discharge to the Willamette over specific time periods. It is evident that discharges from East Doane Lake occur most frequently during rainfall events. It follows logically that these discharges are, in all likelihood, diluted and therefore lower in contaminant concentration than the lake water is when it is not overflowing to the Willamette. During periods of discharge, therefore, the lake discharge may well be within the aquatic criteria, or able to meet the criteria within a small mixing zone as conceptualized and allowed under the Oregon Water Quality Standards.

3.2.1.1 Federal Laws and Regulations

A. Hazardous Waste/Solid Waste

Comprehensive Environmental Response,
Compensation, and Liability Act of 1980 (CERCLA)

Superfund Amendments and Reauthorization Act of 1986

- ° Requirements to meet ARARs.
- ° Preference of treatment over disposal.
- ° Revised screening methods for remedial action alternatives.

Resource Conservation and Recovery Act (RCRA), as amended by PL 99-499, (42 USC 6901) Subtitle C

- ° Protection of ground water (40 CFR 264, Subpart F).

Solid Waste Disposal Act Amendments and Hazardous and Solid Waste Amendments (HSWA) of 1984

- ° Disposal of contaminated soils either on or off site.

B. Water

Safe Drinking Water Act (SDWA) (42 USC 300)

- ° Drinking Water Standards (40 CFR 141).
- ° MCLs - Maximum Contaminant Levels - enforceable standards.

Clean Water Act (CWA) (33 USC 1251)

- ° National Pollutant Discharge Elimination System (NPDES) (40 CFR 122).

- ° The NPDES permit program is administered by the Oregon Department of Environmental Quality.
- ° Applicable in determining acceptable contaminant levels if treated water is discharged into the Willamette River.

C. Air

Federal Air Quality Act (42 USC 7401 - 7642)

- ° Provides for state implementation plans for national primary and secondary ambient air quality standards.
- ° The State of Oregon has been delegated the authority to administer the Federal air quality program.

Clean Air Act (CAA) (72 USC 7401)

- ° National Emission Standards for Hazardous Air Pollutants (NESHAPS)
- ° The NESHAP program is administered by the Oregon Department of Environmental Quality.
- ° EPA has set National Ambient Air Quality Standards (NAAQS) for certain pollutants. Lead is the only pollutant at the Gould site that presently has a NAAQS. Only NAAQS are recommended as ARARs.
- ° Emissions from remedial activities must be considered.

3.2.1.2 Oregon State Laws and Regulations

A. Hazardous Waste/Solid Waste

Oregon Notice of Environmental Hazards Act (ORS 466)

- ° Empowers the State to give notice to local governments of potential hazardous disposal sites and to impose use restrictions on those sites.

Oregon Solid Waste Control Law (ORS 459.005-995)

- ° Provides general provisions for solid waste management including state and local administration, disposal sites, and enforcement.

Oregon Hazardous Waste Management Act (ORS 466.005-995)

- ° Establishes permitting process and rules for treatment, transportation, storage, and disposal of hazardous waste.

Oregon Solid Waste Regulations (OAR 340-61)

- ° Prescribe requirements, limitations, and procedures for storage, collection, transportation, and disposal of solid waste.

Oregon Hazardous Waste Management Regulations (OAR 340-100-108)

- ° Establishes a hazardous waste management system; lists wastes; sets standards for generators, transporters, and owners and operators of TSD facilities; sets permitting procedures.

B. Water

Oregon Water Pollution Control Laws (ORS 468.000-997)

- ° Implement Federal Water Pollution Control Act; set water quality standards; establish permitting process.

Oregon Water Pollution Control Regulations (OAR 340-45 - 340-51)

- ° Establish State Water Quality Maintenance plan; sets regulations for NPDES and WPCF permits.

Oregon Water Quality Standards (OAR 340-41)

- ° Contains plans and standards for managing quality of public waters with specific information on the Willamette basin and contaminants from Gould Inc. site.

C. Air

Oregon Air Pollution Control Laws (ORS 468.005-468.997)

- ° Establishes Department of Environmental Quality, enforcement procedures, air quality standards, permitting process, and regional air quality control authorities.

Oregon Air Pollution Control Regulations (OAR 340-20 - 340-27)

- ° Requires highest and best practicable treatment and control; requires notice of construction and approval of plans; sets procedures for air contaminant discharge permits; sets emission standards.

3.2.1.3 Local Laws and Regulations

A. Planning

- ° Portland Planning Commission - administers planning and zoning for the City.
- ° Portland Development Commission - administers urban renewal and redevelopment; seeks zoning approval from the Planning Commission.

B. Building

- ° Portland Bureau of Buildings - enforces City building code;

issues demolition and building permits based on applicable building codes and other relevant information.

C. Water Supply

- ° Portland Water Bureau - administers the City water system in the Gould Inc. site area.
- ° Multnomah County Watermaster - controls the allocations of water from ground water and surface water bodies.

D. Wastewater Treatment/Discharge

- ° Portland Bureau of Environmental Services, Wastewater Treatment Division - regulates wastewater and installs sampling manholes to check compliance with standards.

E. Drainage

- ° Portland Bureau of Environmental Services, Wastewater Treatment Division - regulates use of storm sewers; applicants must show conformance with NPDES requirements for use of the storm sewer; in the Gould Inc. site area, storm sewer drains into the Willamette River without any treatment.

F. Air Pollution

- ° Oregon Department of Air Quality - administers Federal air quality program.

G. Solid Waste

- ° Portland Bureau of Environmental Services, Solid Waste Division - coordinates the disposal of solid waste.

3.2.2 Screening Methodology and Results

In order to assess the relative merits of the preliminary remedial options in terms of their effectiveness and implementability, a relative score of 1, 2 or 3 (corresponding to low, medium or high) was assigned to them for each of the following attributes:

- ° Effectiveness

- Protectiveness

- Both the short-term hazards and the long-term protection associated with the alternative were considered.

- Reliability

Long-term reliability of engineering and institutional controls were considered, including the type and degree of long-term monitoring required.
- ARARs
- Reduction in toxicity, mobility or volume

The degree that the alternative might reduce site hazards was assessed.
- ° Implementability
 - Technical Feasibility

Difficulties anticipated in constructing and operating the alternative technologies were considered.
 - Availability

The availability of necessary equipment and specialists was appraised.
 - Administrative feasibility

The necessity of coordinating with and obtaining approvals from state and federal offices and agencies was considered. Community and state acceptance of the alternative was also considered.

Preliminary cost estimates include both capital costs, and operating and maintenance costs. For the purposes of the initial screening, rough order-of-magnitude (ROM) costs (-50 to +100 percent) were developed. Since the preliminary cost estimates are for comparison only, costs common to all of the options, such as certain institutional controls, were not included in the estimates. Costs not included in the ROM estimates will in any case be a small fraction of the total cost of the option.

For each of the remedial options developed in Section 3.1, the relative rank and the ROM cost are given in Table 3.2-2. Preliminary costs presented in Table 3.2-2 are based on treating and/or disposing of the various quantities of contaminated material at the site. These quantities, which were determined during the RI, are summarized in Table 3.2-3. Preliminary costs for treating and/or disposing of these materials were generated using information from Means Site Work Cost Data 1987 (Means, 1986), from the Handbook, Remedial Action at Waste Disposal Sites (Revised) (EPA 1985), from the Evaluation of Remedial Action Unit Operations at Hazardous Waste Disposal Sites (J. Ehrenfeld and J. Bass 1984), and from Dames & Moore project files. Preliminary unit costs are presented in Table 3.2-4.

TABLE 3.2-3

ESTIMATED QUANTITIES OF SITE FILL MATERIALS,
USED FOR DEVELOPING PRELIMINARY COST ESTIMATES

	(cu yd)	(cu ft)	(tons)
<u>Soils, Sediments & Matte</u>	<u>28450</u>	<u>768150</u>	<u>39497</u>
Soils	17020	459540	21937
Sediments	5500	148500	5560
Matte	5930	160110	12000
<u>Battery Casings</u>	<u>80000</u>	<u>2160000</u>	<u>75000</u>
Plastic			2400
Ebonite			37125
PbO/Soil	25790	696330	28125
Lead			871
Rock/Debris			6225
Surface Piles	1111	30000	1042
TOTAL	108450	2928150	114497

TABLE 3.2-4
PRELIMINARY UNIT COSTS FOR REMEDIAL OPTION TECHNOLOGIES

Remedial Category	Preliminary Unit Cost*
. Specific Feature	
Surface Soil/Subsurface Soil/Sediments/Matte	
. Remove/Treat/Replace	
Fixation/Stabilization	\$93.61/ton
Chemical Treatment	\$77.68/ton
. Remove/Dispose	\$140/ton
Battery Casings	
. Casings Remove/Treat/Recycle or Dispose	
Component Separation	\$41.63/ton
Off-Site Separation	\$480/ton
Incineration	\$343/ton
Ebonite Incineration	\$328/ton
On-Site Disposal	
Entire Fill	\$85.54/ton
Soil, Sediment & Matte	\$83.96/ton
Battery Casings	\$110/ton
PbO/Soil Mixture	\$92.46/ton
Off-Site Disposal	
Entire Fill	\$157/ton
Soil, Sediment & Matte	\$153/ton
Battery Casings	\$159/ton
Battery Casings Surface Piles	\$132/ton
PbO/Soil Mixture	\$128/ton
Sediments Only	\$158/ton

*Costs are for comparison only. Costs presented are -50 to +100 per-cent.

Using the information presented in Table 3.2-2, the final candidate alternatives are selected. Option 1, the No-Action Alternative, is retained for comparison with the other alternatives, and in accordance with the National Contingency Plan. Option 2 addresses a source of airborne pollution by stipulating removal of the surface piles of battery casings. At the same time, it represents a low-cost option, and incurs the minimum risk from activities associated with site clean-up. Therefore, Option 2 is retained, as well.

Options 3 through 8 employ treatment and/or disposal of sediments as their primary remedial method. Options 6, 7 and 8 additionally stipulate the removal of the surface piles of battery casings. Both Option 4 and Option 7 score lower than the other sediment treatment options, primarily because chemical treatment of sediments is believed to constitute a greater hazard to off-site populations and on-site occupational workers than either fixation/stabilization or off-site disposal. The additional hazard attributed to chemical treatment technologies is due to the possibility of chemical spills. These options are therefore eliminated from further consideration. Since neither Option 3 nor Option 5 addresses the airborne pollution associated with the surface piles, they too are eliminated from further consideration, in favor of Option 6 and Option 8. The costs of Option 6 and Option 8 are within an order of magnitude, so neither can be eliminated on a cost basis. However, off-site disposal of sediments will require less time to implement, requires no testing or development, and is deemed a more certain and final treatment than fixation/stabilization. Therefore, Option 8 will be retained for further consideration, and Option 6 will not be considered further.

Options 9 through 20 employ processing of the battery casing fragments as a principal element. These options are clustered into four groups of 3 options each. In each group, the first option relies on complete separation of the battery casing materials, the second allows mixed lead oxide and soil to be treated with the other fill materials, and the third permits ebonite incineration in addition to lead oxide/soil treatment. The four groups differ in the treatment applied to the remainder of the fill. The first group, options 9, 10 and 11, utilize fixation/stabilization to treat the surface and subsurface soil, sediment and matte. The second group, options 12, 13 and 14, utilize chemical treatment to treat the surface and subsurface soil, sediment and matte. The third group, options 15, 16 and 17, utilizes an on-site disposal vault for disposing of the surface and subsurface soil, sediment and matte. The fourth group, options 18, 19 and 20, calls for

off-site disposal of the surface and subsurface soil, sediment and matte.

Of the options employing processing of the battery casing fragments, Option 10 scores the highest for effectiveness and implementability, and is the only option between 9 and 20 retained for further consideration. As noted above, options which employ chemical treatment generally score lower than options which employ fixation/stabilization, other factors being equal. Options which rely on complete separation of battery casings, and do not allow for treatment of a mixed lead oxide/soil stream - Options 9, 12, 15 and 18 - do not score well due to doubts about the ability of available equipment to perform complete separation. Options which rely on incineration of ebonite - Options 11, 14, 17 and 20 - do not score well due to doubts about the reliability of incineration equipment. Retaining Option 10, however, presumes that recovered ebonite can be recycled. If this is not the case, if no outlet for ebonite can be identified, then Option 10 is no longer a feasible option.

Options 21 through 26 employ disposal of battery casing fragments as a principal element. Three of the options stipulate on-site disposal of the fragments, and three of the options stipulate off-site disposal of the fragments. Two of the options require fixation/stabilization of the remainder of the fill, two require chemical treatment, one requires on-site disposal and one requires off-site disposal. All six of these options scored relatively high for effectiveness and implementability, and all six are quite close in estimated cost. As already discussed, options which employ chemical treatment generally score lower than options which employ fixation/stabilization. Options which specify on-site disposal of fill materials are estimated to be less expensive than analogous options that specify off-site disposal. In addition, on-site disposal of fill materials is deemed slightly preferable to off-site disposal, because on-site disposal eliminates the risks associated with transportation of hazardous materials. For these reasons, Options 21 and 25 are retained for further consideration. The other options in this group will not be considered further.

Options 27 through 30 employ incineration of battery casing fragments as a principal element. Doubts about the reliability of incineration equipment, as well as the administrative feasibility of locating incineration equipment at the site, are reflected in lower scores for these attributes. These options also constitute the most expensive of the options considered, without offering significantly

greater protection for public health or the environment. Options 27 through 30 are therefore eliminated from further consideration.

Selection of the final remedial options for treatment of surface water and ground water does not require the methodical approach taken above for the site fill. A substantial reduction of the remedial options for surface water and ground water can be achieved by consideration of the applicability of the various options to the site. Site characteristics which will affect the applicability of water treatment options are: 1) the humid setting of the site, 2) the placement of the fill partially in the water table, 3) the demonstrated lack of migration of site contaminants in ground water, 4) possible interference of organic contaminants discovered in the ground water with water treatment processes designed for inorganics, and 5) the degree of water treatment required.

These site characteristics render controls for limiting contaminant migration, including leachate plume barriers, both ineffective and infeasible. Since contaminants are not migrating in ground water, any barriers to migration will not accomplish site remedial objectives. Due to the high ratio of precipitation to evaporation, a barrier upgradient of the site may be overtopped by a rising water table, requiring some additional form of water control. In any case, placement of a barrier upgradient of the site would not be expected to lower the water table at the site, since ground water would not be prevented from flowing around the barrier. A barrier surrounding the site, on the other hand, might accumulate water inside its bounds, leading to increased vertical flow through the fill or increased lateral flow through or over the barrier. Even if an impermeable layer were placed on the site in conjunction with an enclosing barrier, ground water would flow under the barrier, causing the site to become a region of stagnant ground water. Because of the depth to bedrock under the site, underflow could not be prevented by securing a barrier to underlying strata. Therefore, options SG1 and SG6 will not be considered further.

The degree of water treatment that will be necessary to achieve ARARs renders in-situ water treatment techniques inapplicable. The likely physical or chemical water treatments will generally result in the site contaminants remaining in the soil, possibly in combination with other precipitates. In addition, methods which have been developed for treating ground water in situ may be sensitive to such diverse factors as the characteristics of ground-water flow, the type of soil comprising the aquifer, the depth of the aquifer, and the nature of the

contaminant. Finally, the introduction of chemicals into the site fill risks their introduction into the ground water. Therefore, options SG4 and SG5 will not be considered further.

For the remaining remedial options, site characteristics, together with characteristics of the site contaminants, will render certain of the water treatment technologies ineffective or infeasible. Sedimentation, filtration and flocculation could be employed to separate solids suspended by excavation activities from surface water; but these processes would not be effective at reducing the amount of dissolved contaminants. Neutralization could be employed to adjust the pH of acidic ground water, but would probably be only slightly effective at reducing the amount of dissolved contaminants.

Precipitation could be employed to reduce the solubility of site contaminants in surface water and ground water. However, as has already been mentioned, the ability of precipitation to remove metal species from solution is often not very good. Adsorption of contaminants on soil particles or the presence of complexants could hold contaminants in solution, in spite of the action of precipitating agents.

Distillation can be used to remove most inorganic compounds from a liquid stream. However, the power requirements and maintenance requirements contribute a high operating and maintenance expense to this technology. Reverse osmosis and ultrafiltration also involve high operating and maintenance costs, and the technical feasibility of employing these methods to remove lead from ground water is unknown.

The final candidate remedial options for surface water and ground water retained through the screening process are listed in Table 3.2-5. These candidate options are described in the following sections, together with the selected candidate alternatives.

3.3 FINAL CANDIDATE ALTERNATIVES

Options for treating the site fill that have been retained through the screening process of Section 3.2 are listed in Table 3.3-1. The final candidate alternatives are constructed by combining these options with technologies for surface treatment, with site monitoring requirements, and with institutional controls. The final candidate alternatives are presented in Table 3.3-2, and are listed in Table 3.3-3.

TABLE 3.2-5

FINAL REMEDIAL OPTIONS FOR SURFACE WATER AND GROUND WATER TREATMENT

Remedial Category Specific Feature	NW	SW1	SW2	SW3	SG2	SG3
Surface Water Treatment						
Surface Water Isolation		X				
Surface Water Remove/ Treat/Replace			X		X	
Surface Water Remove/ Treat/Dispose				X		X
Ground Water Treatment						
Groundwater Remove/ Treat/Replace					X	
Groundwater Remove/ Treat/Dispose						X

TABLE 3.3-1

LIST OF THE FINAL CANDIDATE ALTERNATIVES

OPTION 1

No-Action Alternative

OPTION 2

Removal and Disposal of Surface Piles of Battery Casings

OPTION 8

Removal and Disposal of Surface Piles of Battery Casings
Off-Site Disposal of Sediments

OPTION 10

Battery Casings Component Separation
Fixation/Stabilization of Surface Soil/Subsurface
Soil/Sediments/Matte/(& Possibly Lead Oxide Mixed With
Soil)

OPTION 21

Battery Casings On-Site Disposal
Fixation/Stabilization of Surface Soil/Subsurface
Soil/Sediments/Matte

OPTION 25

On-Site Disposal Option

TABLE 3.3-2

FINAL CANDIDATE ALTERNATIVES

	1	2A	2B	8	10	21	25
Remedial Category							
. Specific Feature							
Site Monitoring							
. Site Monitoring	X	X	X	X	X	X	X
Surface Treatment							
. Lime Treatment		X					
. Paving/Capping, with Revegetation			X	X	X	X	X
Surface & Subsurface Soil & Matte							
. Soil/Matte Remove/Treat/Replace Fixation/Stabilization					X	X	
. Soil/Matte Remove/Dispose On-Site Disposal							X
Off-Site Disposal							
Sediments							
. Sediment Remove/Treat/Replace Fixation/Stabilization					X	X	
. Sediment Remove/Dispose On-Site Disposal							X
Off-Site Disposal				X			
Battery Casings							
. Casings Remove/Treat/Recycle Component Separation					X		
PbO/Soil On-Site Treat/Dispose					X		
. Casings Remove/Dispose Surface Pile Remove/Dispose		X	X	X			
On-Site Disposal						X	X
Off-Site Disposal							
Disposal							
. Residual Disposal					X	X	X
Institutional							
. Institutional Controls	X	X	X	X		X	X
Remedial Classification							
No-Action Alternative	X						
Containment Alternative		X	X	X		X	X
Alternative w/out Long-Term Management of Residuals					X		
Alternative Involving Treatment As a Principal Element					X	X	

TABLE 3.3-3

LIST OF THE FINAL CANDIDATE ALTERNATIVES

ALTERNATIVE 1 No-Action Alternative

Monitoring
Air Quality Monitoring
Monitoring Wells
Monitoring of Surface Water

Institutional Controls
Site Access Restrictions
Land Use Restrictions
Deed Restrictions
Sale Restrictions

ALTERNATIVE 2A

Monitoring
Air Quality Monitoring
Monitoring Wells
Monitoring of Surface Water

Surface Treatment
Lime Treatment
Revegetation

Battery Casings Treatment/Disposal
Casings Removal for Treatment/Disposal (Surface Piles Only)
Off-Site Disposal (Surface Piles Only)

Institutional Controls
Site Access Restrictions
Land Use Restrictions
Deed Restrictions
Sale Restrictions

ALTERNATIVE 2B

Monitoring
Monitoring Wells

Surface Treatment
Paving or Capping
Revegetation

Battery Casings Treatment/Disposal
Casings Removal for Treatment/Disposal (Surface Piles Only)
Off-Site Disposal (Surface Piles Only)

Institutional Controls
Site Access Restrictions
Land Use Restrictions
Deed Restrictions
Sale Restrictions

TABLE 3.3-3 (Continued)

ALTERNATIVE 8

Monitoring
Monitoring Wells

Surface Treatment
Paving or Capping
Revegetation

Battery Casings Treatment/Disposal
Casings Removal for Treatment/Disposal (Surface Piles Only)
Off-Site Disposal (Surface Piles Only)

Sediment Treatment/Disposal
Sediment Removal for Treatment/Disposal
Off-Site Disposal

Institutional Controls
Site Access Restrictions
Land Use Restrictions
Deed Restrictions
Sale Restrictions

ALTERNATIVE 10

Monitoring
Monitoring Wells

Surface Treatment
Paving or Capping
Revegetation

Battery Casings Treatment/Disposal
Casings Removal for Treatment/Disposal
Recycle of Casing Materials
Component Separation
Recycle Sales

Soil, Sediment and Matte (and Possibly Lead Oxide Mixed with
Soil) Treatment/Disposal
Soil, Sediment and Matte Removal for Treatment/Disposal
On-Site Treatment
(Portland Cement, Lime Treatment, Pozzolanic Cementation
or one of the available Proprietary Technologies)

Institutional Controls
Site Access Restrictions
Land Use Restrictions
Deed Restrictions

TABLE 3.3-3 (Concluded)

ALTERNATIVE 21

Monitoring

Monitoring Wells

Leachate Collection System

Surface Treatment

Paving or Capping

Revegetation

Battery Casings Treatment/Disposal

Casings Removal for Treatment/Disposal

On-Site Vault Disposal

Soil, Sediment and Matte Treatment/Disposal

Soil, Sediment and Matte Removal for Treatment/Disposal

On-Site Treatment

(Portland Cement, Lime Treatment, Pozzolanic Cementation
or one of the available Proprietary Technologies)

Institutional Controls

Site Access Restrictions

Land Use Restrictions

Deed Restrictions

ALTERNATIVE 25 On-Site Disposal

Monitoring

Monitoring Wells

Leachate Collection System

Surface Treatment

Paving or Capping

(Asphalt, Portland Cement or Layered Cover System)

Revegetation

Battery Casings Treatment/Disposal

Casings Removal for Treatment/Disposal

On-Site Vault Disposal

Soil, Sediment and Matte Treatment/Disposal

Soil, Sediment and Matte Removal for Treatment/Disposal

On-Site Vault Disposal

Institutional Controls

Site Access Restrictions

Land Use Restrictions

Deed Restrictions

Under the SARA amendments to CERCLA and interim feasibility study guidance from the EPA which implements SARA, final candidate alternatives must include a No-Action Alternative, a containment alternative, at least one alternative which eliminates the need for long-term management of residuals, and at least one alternative which involves treatment as a principal element. The conformance of the final candidate alternatives to these criteria is illustrated in Table 3.3-2.

4.0 DESCRIPTIONS OF THE FINAL CANDIDATE ALTERNATIVES

The screening of the preliminary remedial action alternatives summarized in Section 3.0 eliminated those which would be relatively less protective of the public health or the environment, or which were relatively more expensive without furnishing greater protection. The screening process yielded the group of Final Candidate Alternatives listed in Table 3.3-3.

The Final Candidate Alternatives are fully described in this section. The descriptions include the following, as appropriate:

- ° The goal of the remedial alternative, that is, the general response action categories which the alternative addresses;
- ° Key features of the alternative, such as the associated remedial technologies, and including available information on performance and reliability;
- ° Conceptual design features of major facilities, operating equipment and construction machinery;
- ° Engineering, safety, institutional, environmental and public health considerations that may influence the effectiveness of the alternative;
- ° Maps depicting the extent of the remedial activity;
- ° Operation, maintenance and monitoring requirements; and
- ° General response action categories that the alternative does not address.

Technologies for treating surface and ground water are also considered further in this section. In the development of the detailed descriptions of the alternatives, applicable remedial options for surface water and ground water are examined, and suitable treatment or control methods are presented.

The detailed descriptions of the alternatives provided in this section furnish the basis for the detailed evaluation of the technical, institutional, cost, public health and environmental aspects of the alternatives which is summarized in Section 6.0. The design information presented is, in most cases, of sufficient detail to permit the estimation of alternative costs to within -30 to +50 percent. The design

information presented should not be interpreted as final. Detailed design of the selected remedial action alternative will require careful consideration of public sentiment and agency policy, as well as the refinement of technologies through pilot plant studies and additional site work.

4.1 ALTERNATIVE 1: No Remedial Action

Monitoring: Air Quality Monitoring; Monitoring Wells; Surface Water Monitoring

Institutional Controls: Site Access Restrictions; Land Use Restrictions; Deed Restrictions; Sale Restrictions

Description

The No-Action Alternative is not a category of remedial technologies but a group of activities that can be used to address the contamination problem when remediation measures are not implemented. The activities involve monitoring of the known pollutant pathways. The pathways considered in this alternative are ground water, surface water, soils, vegetation, and airborne.

Ground-Water Monitoring

Ground-water monitoring will be performed twice per year at a minimum of eight sampling points to determine changes in concentration and plume migration. The wells that will be monitored are those located in the study area used for the RI. There are 18 wells at different locations and some having multiple completions providing 31 sampling points in the study area. They are RPW-1D, RPW-2D, RPW-3D, RPW-4D, RPW-5D, W-1D, W-2D, W-3D, W-3D2, W-40, W-6B, W-6D, W-6S, W-7D, W-7S, W-8D, W-9D, W-10D, W-11B, W-11D, W-11I, W-11S, W-120, W-12I, W-12S, W-15D, W-15I, W-15S, W-16D, W-16I, and W-16S. Of these points, the sampling program will include RPW-4D, W-8D, W-9D, W-11S, W-11I, W-11D, W-3B, and W-6D. Points sampled in each period are designed to detect changes in concentration and plume migration.

Airborne Monitoring

Three high volume air monitors (HIVOL) are located on site. These will be supplemented with four more located and installed on adjacent properties. To monitor particulate migration, the seven monitors will be sampled for a 24-hour period, twice per year. This will coincide with the ground-water monitoring program. The filter media from these monitors will be analyzed for lead.

Surface-Water Monitoring

East and West Doane Lakes will be monitored twice per year to determine changes in contaminant levels in the lake water. The sampling program will be performed on a routine basis at the same time as air and ground-water sampling. Sampling will be done by grab sampling methods at two locations in each lake. The four locations will be in approximately the sediment sampling locations utilized in the RI, i.e., SD-1, SD-2, SD-3, SD-4, SD-5, SD-6, SD-10, SD-11, SD-12 and SD-13. The samples will be analyzed for the lead content only.

Surface Soil Monitoring

Surface soils will be monitored annually in the secondary source locations of the Gould and Rhone-Poulenc properties to determine deterioration or improvement of the soils. This will be done in approximately the same locations utilized in the RI phase. Six soils samples will be taken. These will be approximately at SS-4, SS-5, SS-7, SS-9, SS-28, and SS-29. The samples will be analyzed for lead.

Monitoring Report

A report will be prepared after each monitoring event is complete. The document will report the monitoring findings and outline changes and trends from the previous reporting periods.

Institutional Controls

The institutional controls pertinent to the Gould site include water wells restrictions, zoning and land use restrictions, site access restrictions, deed restrictions, and sale restrictions. Institutional controls, which would be an integral part of the No-Action Alternative, are recognized as effective control mechanisms of CERCLA sites. The EPA Study on Institutional Controls from the Office of Policy Analysis (EPA 1987) described the framework for utilizing institutional controls, and precedent is established for their use through several Records of Decision at other CERCLA sites. In particular, the Record of Decision for the Western Processing site contains a provision that "Institutional controls to permanently prevent the extraction and beneficial use of the zone of contaminated ground water will also be necessary prior to site close-out."

Well Permit Restrictions

The Water Resources Department of the State of Oregon has responsibility for ground water use. No permit is required for a domestic well of 15,000 gallon per day or an industrial well of 5,000 gallons per day. Above these levels a water right application permit would have to be issued by the Water Resources Department.

Site Access Restrictions

The site is fenced at the present time which is adequate to prevent public access. Because of potential human health effects, Doane Lake will be posted to warn intruders against drinking the water or swimming.

Zoning Restrictions

The Planning and Zoning Bureau of the City of Portland is responsible for zoning designations. The zoning designation is currently heavy industrial. Continuation of the industrial zoning would limit residential and public land use. The Bureau of Buildings has enforcement responsibilities for city building and zoning code. The Permit Center of the City of Portland issues building permits based on applicable building codes, zoning ordinance, completion of an environmental checklist, and records filed with the Center which could relate to environmental problems. The Permit Center has representatives from the various bureaus, including planning and zoning, building, environmental, etc.

Land Use Restrictions

In 1985 the State of Oregon enacted the Oregon Notice of Environmental Hazards Act (ORS Chapter 466). Under this legislation, the State is empowered to give notice to local governments of potential hazardous disposal sites and to impose use restrictions on those sites. At a minimum, the notice must restrict post-closure use of the site to those activities that will not disturb the components of any containment system for site contaminants. Such restrictions at the Gould site could be used to mitigate risks from contaminants by alerting all users of the site to limitations posed by the presence of contaminants.

Deed Restrictions

An owner may, within the confines of the law, voluntarily place notations on a property deed, or on some other instrument which is normally examined during a title search. Such notations or recordings could include restrictions against certain uses of a property, such as certain types of development or exploration, including well drilling. Such a mechanism would be used by Gould under the No-Action Alternative to prohibit the installation of ground-water withdrawal wells on the Gould site.

Sale Restrictions

Among the rights a property owner possesses, in addition to the right to impose voluntary deed restrictions, is the right to legally bind the owner, his heirs, and his successors to a commitment that the property will not be sold in perpetuity. As with deed restrictions, such a legal commitment can consist of a notation on the property deed, or on some other instrument which is normally examined during a title search. In practice under this alternative, Gould Inc. would make such a commitment for the Gould site. As a further protection, Gould Inc. would commit to reassess the need for remediation under CERCLA or a successor law in effect at the time, should Gould Inc. ever decided to pursue a sale of the property.

4.2 ALTERNATIVE 2A

Monitoring: Air Quality Monitoring; Monitoring Wells; Monitoring of Surface Water

Surface Treatment: Lime Treatment

Battery Casings Treatment/Disposal: Casings Removal for Treatment/Disposal (Surface Piles Only); Off-Site Disposal (Surface Piles only)

Institutional Controls: Site Access Restrictions; Land Use Restrictions; Deed Restrictions; Sale Restrictions

Description

Under this alternative, most of the fill material would be left in place, thereby avoiding possible off-site exposure to site contaminants due to fill excavation and handling. Only the surface piles of battery casing fragments, which presently constitute the major source of air-borne pollution from the site, would be removed for off-site disposal.

The removal and disposal of the surface piles of battery casing fragments would reduce the airborne hazards associated with the Gould site. Surface treatment of the Gould site by the application of lime would reduce the migration of site contaminants in surface water and ground water. By raising the pH of water infiltrating the fill, lime treatment would reduce the solubility of lead in the water, thereby reducing lead migration. Thermodynamic considerations alone suggest that lead solubility would be reduced to less than 20 ug/l for a soil pH of between 8.2 and 9.1. Because most of the site contaminants would be left in place, however, this alternative does not act to reduce surface or subsurface contamination. In addition, this alternative may provide only minimal control of airborne contaminant migration.

Institutional controls would be used under this alternative to restrict public access to remaining site contaminants, to potentially contaminated ground water and to surface water. Institutional control over ground-water access would be implemented, as in the No-Action Alternative, through deed and sale restrictions. Periodic sampling and analysis of ground water using the monitoring systems described under the No-Action Alternative will be used to verify the effectiveness of the surface treatment, and to confirm that site contaminants are prevented from migrating off site.

Surface Casing Removal

The removal and disposal of the surface piles of battery casing fragments would be accomplished using conventional earthmoving machinery. A wheel loader or other standard excavator would be employed to load the waste into transport vehicles, for direct conveyance to a landfill off site. Three of the battery casing surface piles consist of a heterogeneous mixture of plastic, ebonite, lead and miscellaneous byproduct materials. A survey of these three piles provided a volume estimate of nearly 30,000 ft³. The fourth pile consists mostly of ebonite, and contains roughly 17,000 ft³ of material. The overall grade of the site would not be altered under this alternative, except by the removal of the surface piles: since the percolation of rain through the surface soils will leach lime, the natural slope of the site will transport lime over the surface of the site to the East Doane Lake remnant. The seepage of lime into the lake will act to gradually increase the pH of the lake water, thereby decreasing the amount of dissolved lead.

Lime Application

Application of lime would be preceded by thorough watering of the surface to inhibit the generation of dust. The upper one and one-half feet of soil would then be tilled to break up the surface crust. Next, dry lime would be applied to the surface. The quantity of lime needed to increase soil pH to above 8.2 would be estimated from pilot studies conducted prior to treatment. The exact quantity necessary would be determined by field measurements. The maximum amount of lime recommended for supporting agriculture is 6 tons per acre; and the maximum amount recommended for a single application is 4 tons per acre, because larger quantities can be difficult to mix completely (D.R. Christenson, D. D. Warncke and R. Leep, 1983). Larger quantities are frequently used for cementing soils; soil cementation, however, is not the purpose of this alternative.

Immediately after applying lime to the surface, watering would be repeated. Then, a disc would be employed to mix the lime into the fill. Discing would be followed by repeated application of lime, if necessary; by re-watering and discing to mix the additional lime; and finally by soil compaction.

Those areas that will be affected by excavation or lime treatment, depicted in Figure 4.2-1, are those areas where surface soils or debris fail EP Toxicity results for lead, or where buried source materials are located.

Off-Site Disposal

All technologies considered for handling source materials at the site are discussed in Section 2.3 of the report. Given the relatively small volume of battery casing fragments in the surface piles, off-site disposal is the most feasible disposal method. RCRA manifest requirements must be met for the transportation and disposal of all dangerous or extremely hazardous waste. In addition, the waste generator should ensure that the facility selected to receive the waste is in compliance with all applicable federal and state environmental and public health statutes. The nearest approved hazardous waste landfill is the Chem Securities facility in Arlington, Oregon. The battery casing fragments would be transported in 20-ton dump trucks in bulk. Complete sealing of the material in the trucks would be ensured during transport.

Institutional Controls

The institutional controls appropriate to the Gould site include controls on water wells, zoning and land use restrictions, sale restrictions and site access restrictions. As shown in Figure 4.2-2, the zoning designation of the site and vicinity is heavy industrial (HI) at present. Maintenance of the present zoning would limit residential and public land use. The Building and Zoning Department has the responsibility for enforcing the city building and zoning codes. This department issues demolition and building permits based on applicable building codes and zoning ordinances, and after completion of an environmental checklist and a search of department records for files relating to environmental problems. This system could be used to require treatment of subsurface fill on the Rhone-Poulenc property, for example, prior to development. In general, the site could not be developed or modified without assurance that appropriate actions would be taken to control the onsite contaminants.

Operation and Maintenance

Regular inspection of the site, together with a long-term monitoring program, will be needed to ascertain the continuing effectiveness of the lime treatment method. The required long-term monitoring program would be the same as that described in Section 4.1 for the No-Action Alternative. In non-traffic areas, limited durability of the surface layer will demand maintenance and replacement during the 30-year design period, perhaps as frequently as every three years. The actual frequency of replacement would be determined based on air monitoring results, ground-water monitoring results, and visual observation. For cost purposes, replacement every three years is assumed.

4.3 ALTERNATIVE 2B

Monitoring: Monitoring Wells; Air Monitors

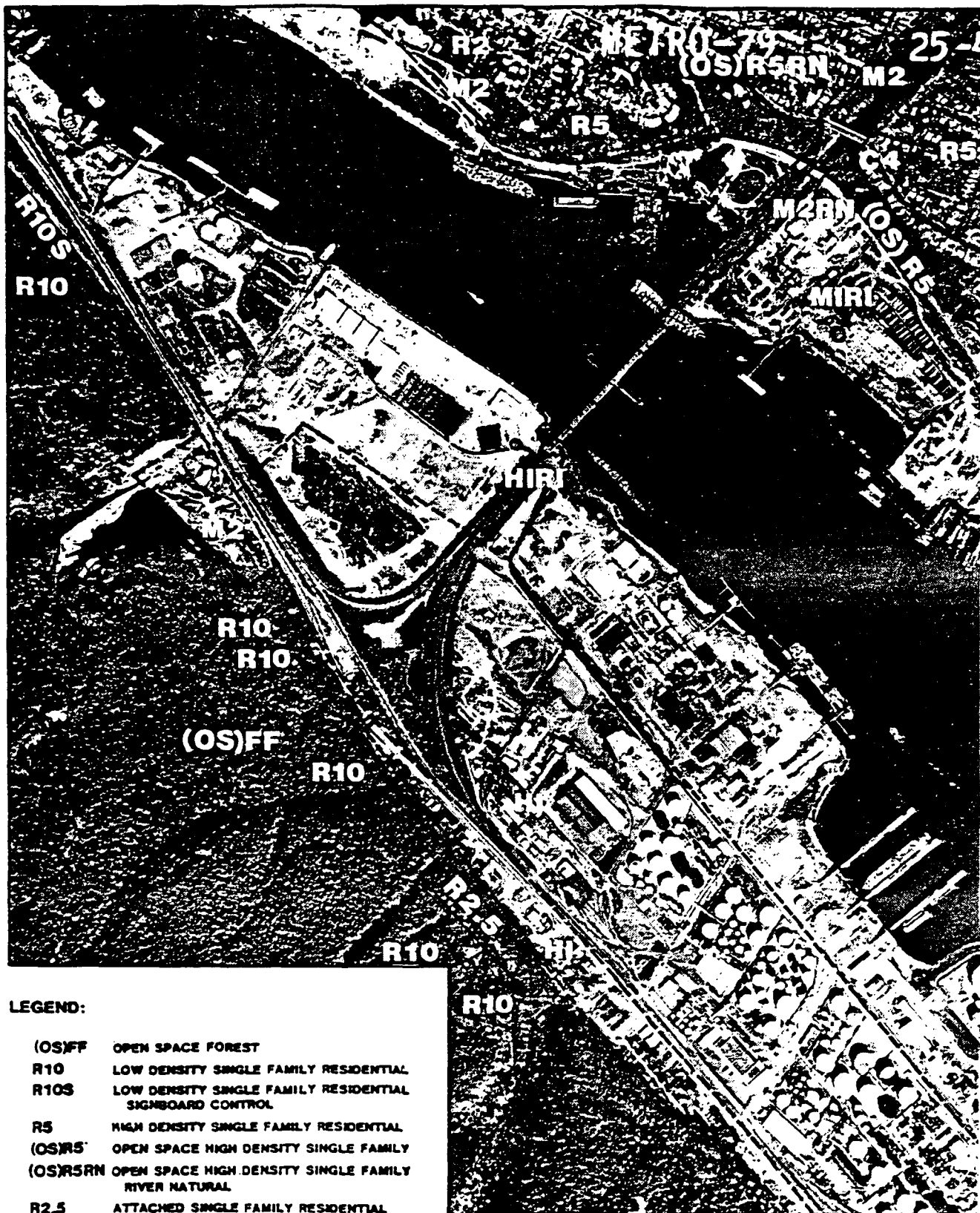
Surface Treatment: Capping; Revegetation

Surface Water: Isolation of East Doane Lake

Ground Water: Institutional Controls

Battery Casings Treatment/Disposal: Casings Removal for Treatment/Disposal (Surface Piles Only); Off-Site Disposal (Surface Piles Only)

Institutional Controls: Site Access Restrictions; Land Use Restrictions; Deed Restrictions; Sale Restrictions



LEGEND:

(OS)FF	OPEN SPACE FOREST
R10	LOW DENSITY SINGLE FAMILY RESIDENTIAL
R10S	LOW DENSITY SINGLE FAMILY RESIDENTIAL SIGNBOARD CONTROL
R5	HIGH DENSITY SINGLE FAMILY RESIDENTIAL
(OS)R5	OPEN SPACE HIGH DENSITY SINGLE FAMILY
(OS)R5RN	OPEN SPACE HIGH DENSITY SINGLE FAMILY RIVER NATURAL
R2.5	ATTACHED SINGLE FAMILY RESIDENTIAL
R2	LOW DENSITY MULTI FAMILY RESIDENTIAL
C4	NEIGHBORHOOD COMMERCIAL
M2	GENERAL MANUFACTURING
M2RN	GENERAL MANUFACTURING RIVER NATURAL
MIRI	HEAVY MANUFACTURING RIVER INDUSTRIAL
HI	HEAVY INDUSTRY
HIRI	HEAVY INDUSTRY RIVER INDUSTRIAL

NL IND, INC./GOULD, INC.
FEASIBILITY STUDY

EXISTING LAND USE AND
ZONING CODE DESIGNATIONS

FIG. 4.2-2

DAMES & MOO

11831-034

SCOEPAA00004506

Description

Under this alternative, as under Alternative 2A, the fill material would be left in place, thereby avoiding possible off-site exposure to site contaminants due to fill excavation and handling. Only the surface piles of battery casing fragments, which presently constitute the major potential source of airborne pollution from the site, would be removed for off-site disposal.

The removal and disposal of the surface piles of battery casing fragments would reduce the airborne hazards associated with the Gould site. Removing the surface piles of battery casing fragments would also ease site capping. Capping of the site would reduce airborne contaminant migration to an acceptable level, and would be accompanied by site regrading to reduce the migration of site contaminants in surface water. Regrading would be used to direct runoff away from the East Doane Lake remnant. The existing outlet of the lake to the Willamette River would be plugged, eliminating this outlet as a path for contaminant migration off site. This alternative acts to control vertical contaminant migration in ground water by eliminating the direct infiltration of water through the surface.

Institutional controls would be used under this alternative to restrict public access to remaining site contaminants, to potentially contaminated ground water and to water remaining in the East Doane Lake remnant. Periodic sampling and analysis of ground water employing the well monitoring systems described under the No-Action Alternative will be used to verify that site contaminants are prevented from migrating off site.

Surface Pile Removal

The removal and disposal of the surface piles of battery casing fragments would be accomplished using conventional earthmoving machinery. A wheel loader or other standard excavator would be employed to load the waste into transport vehicles, for direct conveyance to a land-fill off site. As previously discussed, three of the battery casing surface piles consist of a heterogeneous mixture of plastic, ebonite, lead and miscellaneous byproduct materials, and the fourth pile consists mostly of ebonite.

Following the removal of the surface piles of battery casing fragments, the site would be regraded to direct runoff away from the East Doane Lake remnant. Regrading would be accomplished using a wheel

tractor scraper and a grader. A swale would be raised along the southwest side of the lake, along the American Steel property line and across the Gould property. Runoff collected behind this swale would be directed into a drain on the Gould property, and piped into the storm sewer system for discharge into the Willamette River. Without the recharge provided by surface runoff, the East Doane Lake remnant would no longer require an overflow to the Willamette River, and the existing overflow channel could be blocked.

Surface Treatment

The surface treatment would consist of a soil/bentonite cap applied over the fill materials in four layers. Soil containing roughly 18 to 24 percent bentonite by weight would be applied to form a cover layer 2-feet thick; the exact mix of soil and bentonite would be determined by pilot-scale testing at the site. This soil/bentonite surface cap would be covered by a layer of topsoil 4 inches thick. Revegetation of the site using hydroseeding or a comparable technology would stabilize the surface cap, assist in controlling erosion, and improve the final appearance of the site.

The areas that will be affected by excavation, regrading or surface capping match the areas that would be affected under Alternative 2A, and are depicted in Figure 4.2-1.

Off-Site Disposal

As discussed under Alternative 2A, given the small volume of battery casing fragments in the surface piles, off-site disposal is the most feasible disposal method. RCRA manifest requirements must be met for the transportation and disposal of all hazardous wastes; the waste generator will ensure that the facility selected to receive the waste is in compliance with all applicable federal and state environmental and public health statutes. The nearest approved hazardous waste landfill is the Chem Securities facility in Arlington, Oregon. The battery casing fragments would be transported in 20-ton dump trucks in bulk. Complete sealing of the material in the trucks would be ensured during transport.

Institutional Controls

As already discussed, the institutional controls appropriate to the Gould site include controls on water wells, zoning and land use restrictions, sale restrictions, and site access restrictions. Maintenance of

the present zoning would limit residential and public land use. In general, the site could not be developed or modified without assurance that appropriate actions would be taken to control the onsite contaminants.

Operation and Maintenance

Regular inspection of the site, together with a long-term ground-water monitoring program, will be needed to ascertain the continuing effectiveness of the treatments employed under Alternative 2B. The required air and ground-water monitoring program would be the same as that described in Section 4.1 for the No-Action Alternative.

4.4 ALTERNATIVE 8

Monitoring: Monitoring Wells; Air Monitors

Surface Treatment: Capping; Revegetation

Surface Water Treatment: Filtration/Flocculation; Isolation of East Doane Lake

Ground Water: Institutional Controls

Battery Casings Treatment/Disposal: Casings Removal for Treatment/Disposal (Surface Piles Only); Off-Site Disposal (Surface Piles Only)

Sediment Treatment/Disposal: Sediment Removal for Treatment/Disposal; Off-Site Disposal

Institutional Controls: Site Access Restrictions; Land Use Restrictions; Deed Restrictions; Sale Restrictions

Description

This alternative consists of removing and disposing of the surface piles of battery casing fragments, excavating and disposing of the East Doane Lake sediments, and surface capping. As under Alternatives 2A and 2B, fill material other than the lake sediments and the surface piles of battery casing fragments would be left in place, thereby avoiding possible off-site exposure to site contaminants due to fill excavation and handling. As previously noted, surface piles of battery casing fragments constitute the major potential source of airborne pollution from the site. Surface capping would eliminate airborne contaminant migration entirely, and would be accompanied by site regrading to reduce the migration of site contaminants in surface water. The existing outlet of the lake to the Willamette River would be plugged, eliminating this outlet as a path for contaminant migration off site.

Because they are in intimate contact with surface water in the East Doane Lake remnant, the lake sediments constitute a possible source of surface water contamination. Removal of the sediments would prevent further contamination of the lake water by eliminating this contaminant source. While the sediments are being excavated, however, substantial mechanical mixing is likely to occur. The mixing of sediments with the lake water may result in elevated levels of contaminants in the water, in the form of either dissolved species or suspended solids. After the sediments have been removed, the suspended or dissolved contaminants might redeposit on the lake bottom, thereby reestablishing a source of continuing pollution. Treatment of surface water by filtration and flocculation while sediment excavation proceeds will maintain contaminant concentrations in the water at reasonable levels, preventing suspended solids from bypassing the sediment removal operation. This alternative acts to control vertical contaminant migration in ground water by eliminating the direct infiltration of water through the surface.

Institutional controls would be used under this alternative to restrict public access to remaining site contaminants, to potentially contaminated ground water and to water remaining in the East Doane Lake remnant. Periodic sampling and analysis of ground water employing the well monitoring systems described under the No-Action Alternative will be used to verify that site contaminants are prevented from migrating off site.

Excavation

It is assumed that cleanup of sediments in the East Doane Lake remnant will require the removal of about one foot of the lake bottom. The sediments will probably contain rocks and battery casing fragments. Sediments may be removed using a dragline or by dredging: a dragline with a 60- to 70-foot boom crane is the prime candidate for sediment excavation.

As under Alternatives 2A and 2B, the removal and disposal of the surface piles of battery casing fragments would be accomplished using conventional earthmoving machinery. A wheel loader could be employed to load the fragments into transport vehicles; however, employing a dragline for both the surface piles and the sediments may be more practical and more cost-effective.

Following the removal of the sediments and the surface piles of battery casing fragments, the site would be regraded to direct runoff

away from the East Doane Lake remnant. A swale would be raised along the southwest side of the lake, along the American Steel property line and across the Gould property. Runoff collected behind this swale would be directed into a storm drain on the Gould property, and piped into the storm sewer system for discharge into the Willamette River. Without the recharge provided by surface runoff, the East Doane Lake remnant would no longer require an overflow to the Willamette River, and the existing overflow channel would be blocked.

The surface treatment would consist of a soil/bentonite cap applied over the fill materials in four layers. Soil containing roughly 18 to 24 percent bentonite by weight would be applied to form a cover layer 2-feet thick; the exact mix of soil and bentonite would be determined by pilot-scale testing at the site. This soil/bentonite surface cap would be covered by a layer of topsoil four inches thick. Revegetation of the site using hydroseeding or a comparable technology would stabilize the surface cap, assist in controlling erosion, and improve the final appearance of the site.

The areas that will be affected by excavation, regrading or surface capping are depicted in Figure 4.4-1.

Off-Site Disposal

As discussed previously, given the small combined volume of sediments and battery casing fragments in the surface piles, off-site disposal is the most feasible disposal method. RCRA manifest requirements must be met for the transportation and disposal of all hazardous wastes; and the waste generator must ensure that the facility selected to receive the waste is in compliance with all applicable federal and state environmental and public health statutes. The nearest approved hazardous waste landfill is the Chem Securities facility in Arlington, Oregon. The sediments and battery casing fragments would be transported in 20-ton dump trucks in bulk. Complete sealing of the material in the trucks would be ensured during transport.

Institutional Controls

As already discussed, the institutional controls appropriate to the Gould site include controls on water wells, zoning and land use restrictions, sale restrictions and site access restrictions. Maintenance of the present zoning would limit residential and public land use. In general, the site could not be developed or modified without assurance that appropriate actions would be taken to control the onsite contaminants.

Operation and Maintenance

Regular inspection of the site, together with air and ground-water monitoring, will be needed to ascertain the continuing effectiveness of the treatments employed under Alternative 8. The required groundwater monitoring program would be the same as that described in Section 4.1 for the No-Action Alternative.

4.5 ALTERNATIVE 10:

Soil/Sediment Treatment/Disposal: Fixation/Stabilization of Surface Soil, Subsurface Soil, Sediments, and Matte

Surface Treatment: Surface Capping and Revegetation

Battery Casings Treatment/Disposal: Separation of Battery Casing Components

Surface Water: Isolation of East Doane Lake; Filtration/Floculation

Ground Water: Institutional Controls

Description

Surface soils and sub-surface soils contaminated with levels greater than 3,000 ppm total lead (assumed EP Toxicity of 5 ppm) and the sediments and matte will be removed and treated with a fixation additive to bind the lead in the soils matrix. The battery casings will be removed and treated to separate the component materials such that they can be recycled or disposal of off site. These two actions will mitigate the airborne and sub-surface materials problems. The stabilized product from the soils process will be backfilled, graded, and recompact. A soil cap and vegetative cover will be placed over the backfill to prevent weathering of stabilized soil and subsequent remobilization of the metal components. East Doane Lake will be isolated and the site graded to prevent surface drainage entering the lake. The following describes the process and unit operations.

Earthmoving

The contaminated surface soils will be removed by bulldozers and motor scrapers, and stockpiled adjacent to the soils treatment facility. The surface soil quantity is as shown in the table below.

The subsurface contaminated soil sediments and matte will be removed, using a dragline or backhoe for the mass excavation. Loaders and bulldozers will be used for clean-up. The bulldozer will also be used to break up the large pieces of sediments and matte to a minus 8

inch size. Surface and subsurface soil volumes with contamination above 3,000 ppm total lead, and the other waste materials are estimated to be the following:

	<u>Volume</u> <u>(cu yd)</u>	<u>Mass</u> <u>(tons)</u>
Surface Soils	3,370	4,344
Sub-surface Soils	13,650	17,593
Sediments	5,500	5,560
Matte	5,930	12,000
Battery Casings	80,000	75,786

Dump trucks will transfer the contaminated soils to a stockpile adjacent to the soils treatment facility. Soils less than 3,000 ppm removed for ease of access and slope stability will be stockpiled and later used as backfill. This volume is estimated to be 17,800 cu. yd.

To prevent run-off into East Doane Lake, the site will be graded away from the shoreline. In addition to the earthmoving required on the Gould site, the northeast section of the American Steel Industries parking lot, which drains to the lake, will require modification. This will involve removing approximately 2,600 square feet of asphalt, installing a drain system discharging to the Gould site, and repaving the area.

The excavation of subsurface battery casings and subsequent treatment will result in an extension of East Doane Lake. To prevent erosion, the excavation will be graveled at the shoreline and coarse gravel will be spread and graded for three feet above and below the waterline.

To prevent excess airborne migration during surface and subsurface excavation of material, dust control will be practiced as required.

Battery casings will be excavated by loader and backhoe. Dump trucks will be used to deliver the casings to a stockpile located adjacent to the battery casing treatment plant. The casing quantities are as shown above.

The treated soils will be back hauled to the excavation by trucks and motor scrapers, then graded and compacted in lifts suitable for the soil type. The site will be graded to have swales and slopes to provide soil stability, drainage, and prevent run-on from adjacent areas. Top soil will be imported to provide a three inch soil cap with a vegetative cover to prevent weathering and subsequent airborne migration.

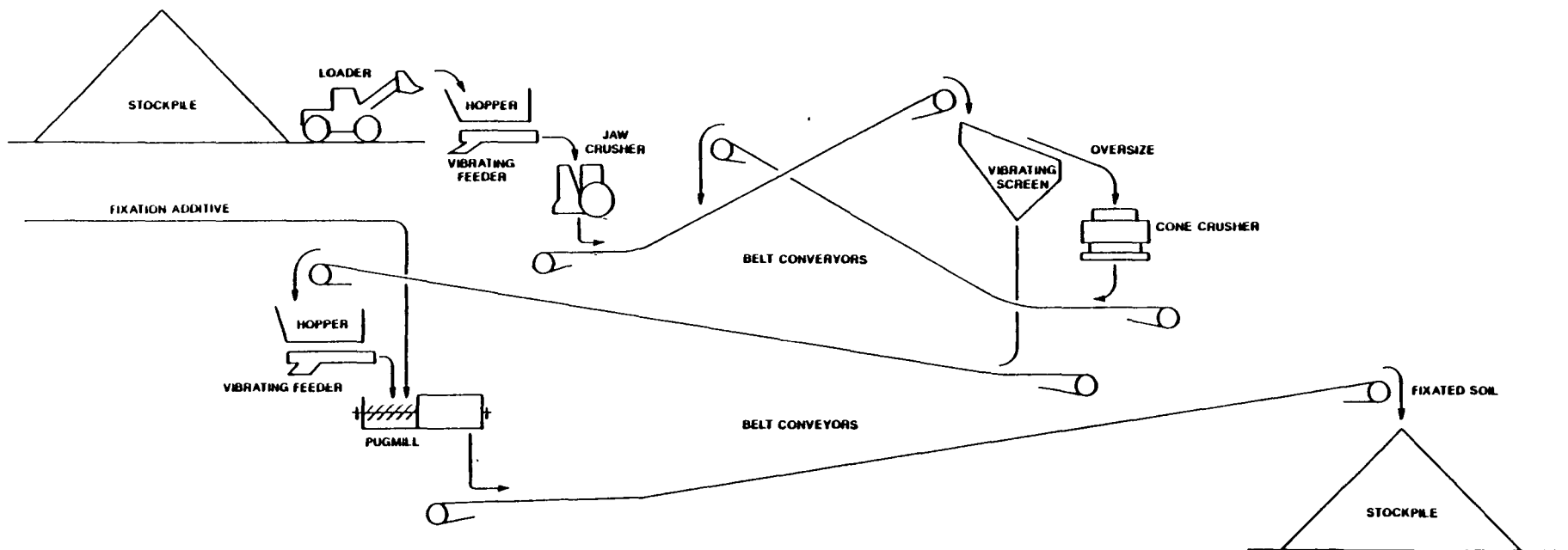
Soils Treatment Facility

A treatment facility will be constructed at the site to treat contaminated subsurface materials. The process is depicted on the flow diagram on Figure 4.5-1, and consists of a comminution system to reduce the materials to a relatively uniform size, and then pugmilling with an additive to bind the metals in the soils matrix. It is assumed for purposes of this study that the material size required for successful pugmilling is 100 percent minus 1/4 inch.

The crushing facility is comprised of two stages of crushing (jaw and cone), with a vibrating screen in close circuit with the cone crusher. The system is interconnected with belt conveyers. The subsurface materials that are stockpiled adjacent to the treatment facility are fed in a hopper at the start of conveying system by loader. The sub-surface materials in the hopper are drawn down by a vibrating feeder at a rate of 10.5 tons per hour and discharged to a belt conveyor that feeds the jaw crusher.

The jaw crusher reduces all materials to 100 percent minus 1.5 inch and discharges it to a conveyor, feeding the vibrating screen. At the screen it is joined with the material from the cone crusher, and the minus 1/4 inch material is screened out. The screen oversize is directed to the cone crusher which reduces the material to 50 percent, minus 1/4 inch. The cone crusher product is transported by conveyor to join the jaw crusher material at the feed to the vibrating screen. The screen undersize (minus 1/4 inch) is transported to the pugmilling system feed hopper.

In the pugmilling section, the process commences at the feed hopper which provides a total surge capacity of one hour between the two systems. Stockpiling, retrieval, material handling, and circulating loads in the crushing circuit have now provided a uniform blend of feed material to the pugmill. The contents of the hopper are drawn down by vibrating feeder at a constant rate of 12 tons per hour. The feeder discharges the material to the pugmill where it is joined with binder additive and a predetermined amount of water. Dependent on the type of additive, it is fed to the pugmill either as a slurry or as a dry material by feeder. In the pugmill the additive is driven into the soils by paddle and a required amount of electromotive energy. The additive comprise of a cementitious fixative (cement, pozzolan, lime, clays); a reducing agent, and various proprietary chemicals. The actual additive composition and its ratio will be determined by pilot testing



NL IND., INC./GOULD INC.	
FEASIBILITY STUDY	
SOILS TREATMENT FACILITY	
FIG. 4.5-1	DAMES & MOORE

during the design phase. The pugmill discharges the stabilized soil to a belt conveyer which transports it to a stockpile from where it can be retrieved by loader for backfilling.

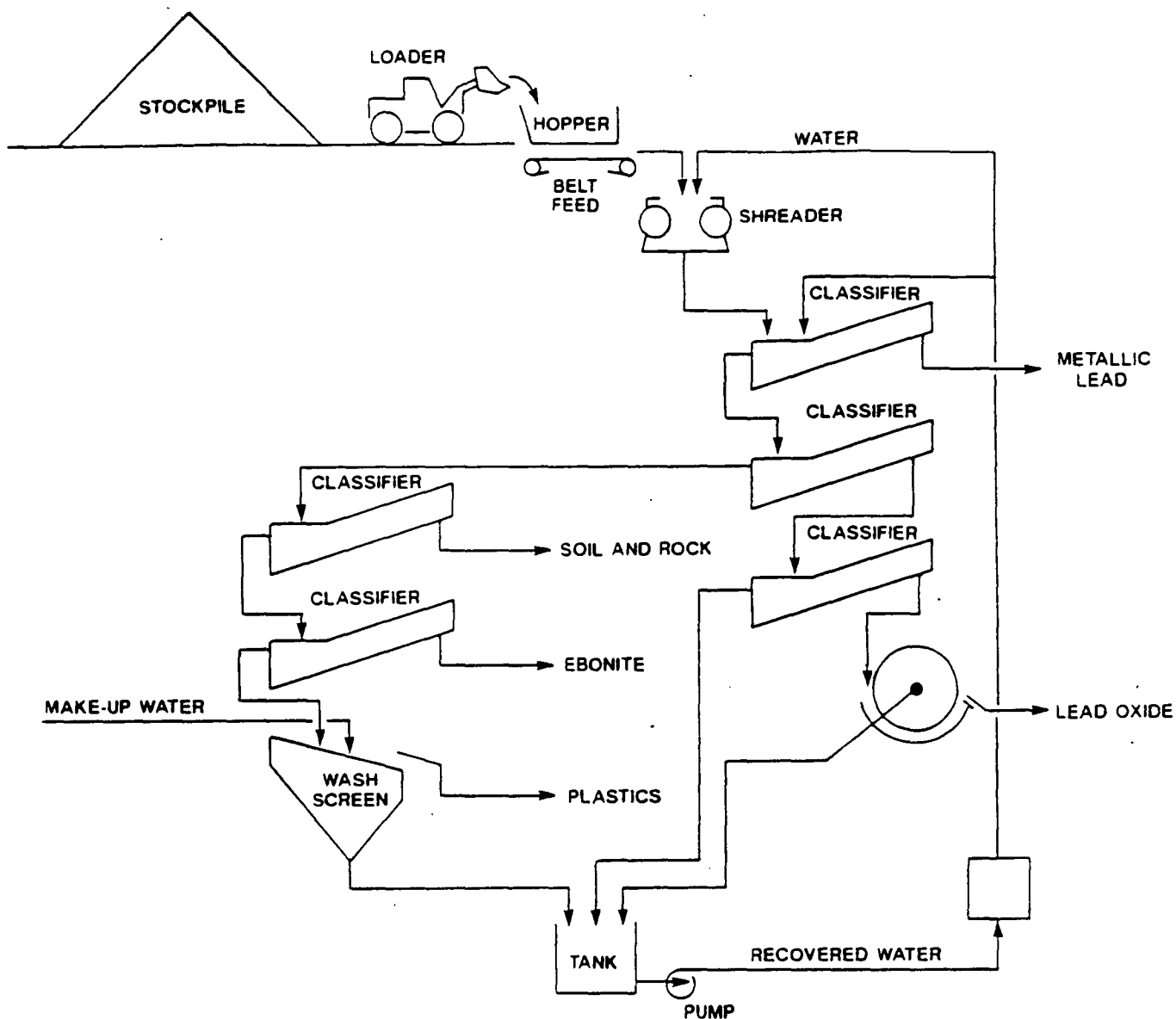
Battery Casing Treatment Plant/Ebonite Treatment Plant

A treatment facility will be constructed at the site to treat the contaminated battery casings and produce potentially recyclable products or a reduction in material to be subsequently disposed. The process is depicted on the flow diagrams in Figures 4.5-2 and 4.5-3, and consists of a comminution system to reduce the materials to a size at which they can be separated. This is followed by a series of hydroclassifiers which separate the various products in water by the differential specific gravities. Separation is performed as a function of material specific gravity and detention time in each classifier. Ebonite is then ground in a separate treatment facility. The quantities and specific gravities of each of the casing components are estimated to be the following:

<u>Component</u>	<u>S.G.</u>	<u>Bulk Density (lbs/cu.ft.)</u>	<u>Bulk Vol. (cu. yd.)</u>	<u>Mass (tons)</u>
Plastics	0.94	32.51	5,544	2,433
Ebonite	1.55	36.51	76,370	37,643
Rock/Debris	2.72	75.00	6,234	6,312
Lead Oxide	9.10	214.37	9,854	28,517
Metallic Lead	11.34	267.46	244	881
Average/Total	4.60	57.14	98,246	75,786

The process starts with the casings being recovered from the stockpile by loader and discharging them into a conveyer feed hopper. The hopper is drawn down by a belt feeder which feeds the conveyor belt at the constant rate of 20.2 tons per hour. The conveyor feeds a shredder or hammer mill which reduces the casing materials to 100 percent - 1/2 inch. The shredder is washed constantly with a spray of recycled process water. The shredder products, including the water, discharge into the first hydroclassifier.

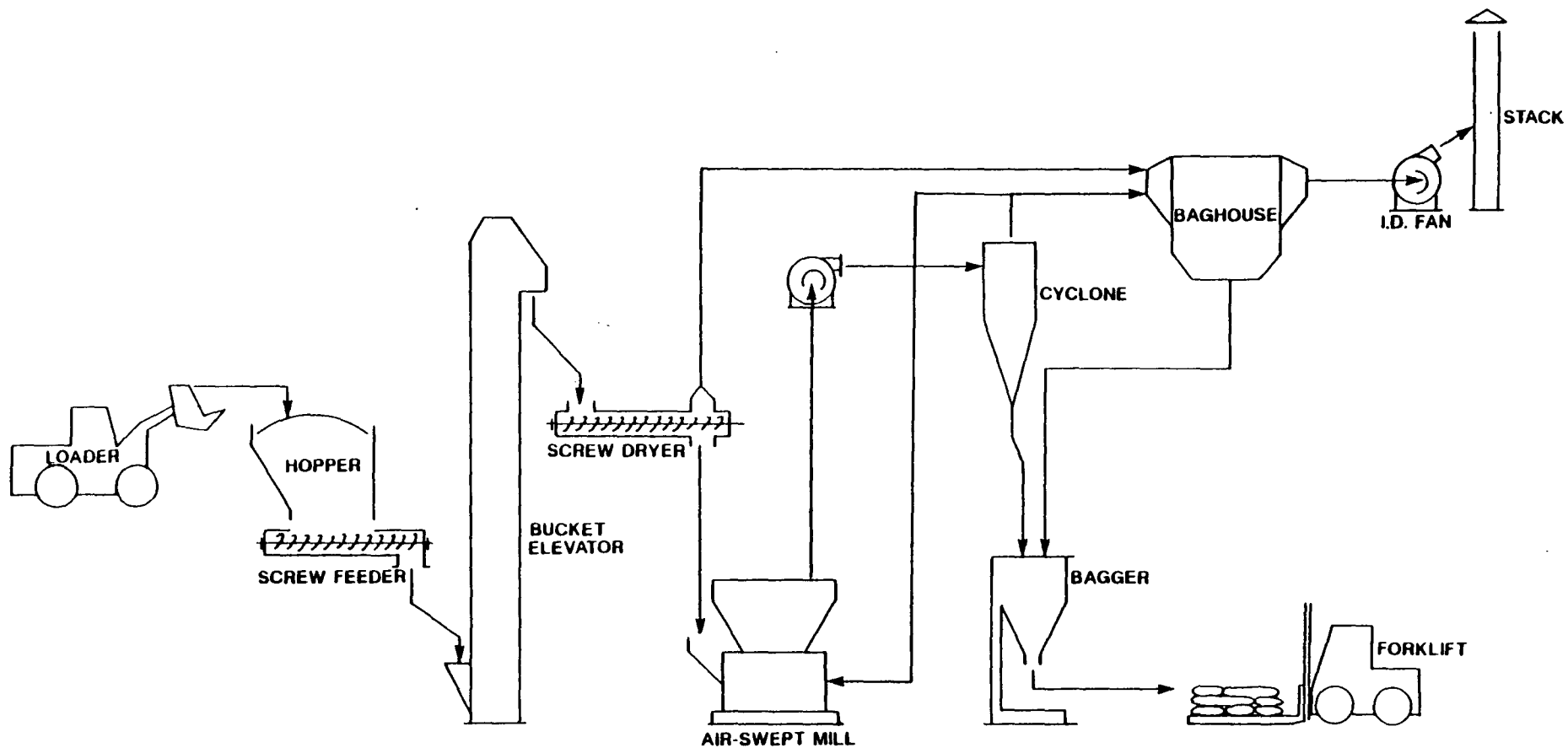
Since the components having a higher mass settle most rapidly, metallic lead will be removed in the first classifier, lead oxide in the second, rock and debris in the third, and so forth. Since lead oxide is a very fine material, two classifiers stages are required to scavenge the material from the liquid. The oxide also carry over more water (about 20 percent by weight) which requires that it be passed through a filter to reduce it to 10 to 12 percent. All other materials discharged



NL IND., INC./GOULD INC.
FEASIBILITY STUDY

BATTERY CASING
TREATMENT FACILITY

FIG. 4.5-2 DAMES & MOOR



NL IND., INC./GOULD, INC.
FEASIBILITY STUDY

EBONITE TREATMENT PLANT.

FIG. 4.5-3

DAMES & MOORE

carry over about 12 percent moisture by weight. The last classifier separates the ebonite and plastics. The ebonite is discharged with about 12 percent moisture and the plastics with about 98 percent moisture. This will be then passed through a dewatering vibrating screen. Water recovered from the dewatering screen and oxide dewatering is gathered in a tank from which it is pumped and recycled to the process.

Ebonite Treatment Plant

A treatment facility will be constructed at the site to reduce the size and bag the ebonite for sale in the drilling mud market. The process is described graphically in Figure 4.5-3 and consists of a drying system to reduce the excess moisture to less than five percent and a comminution system to reduce the ebonite to about 200 mesh (U.S. Sieve). This is followed by a bagging system which places and seals the material in paper sacks for shipment.

The process commences with a wheeled loader picking up the ebonite from a stockpile in the Battery Casing Treatment Plant. The loader discharges the ebonite to a feed hopper in the Ebonite Treatment Plant. The hopper is drawn down by a screw feeder which discharges to the ebonite at a constant rate of 10 tons per hour to a bucket elevator. The bucket elevator raises the material 12 feet and discharges it to a screw dryer. The screw dryer is electrically heated and air is swept through it by an I.D. fan. This action drives-off the moisture as vapor in the air which is directed to a baghouse dust collector. The screw discharges the dry ebonite directly into an air-swept mill.

In the mill, the ebonite is crushed by rollers. Air is drawn up through the mill mobilizing and removing the ground particles. The exhausted air stream is directed through ducts to a cyclone. In the cyclone, the particles are separated from the air by vortex action and discharged through the bottom (apex). The recovered air is returned through the mill providing the up-draft air for further particle transportation. A small portion of the cyclone recovered air is bled-off to the baghouse dust collector. The ground particles discharged from the cyclone apex are directed through an enclosed chute to a bagging machine. At the bagging machine the ground ebonite is discharged in measured volume to paper sacks. The machine seals the sacks and then they are removed and placed on pallets for storage and transportation.

The exhaust air and vapor from the dryer and the air bled from the cyclone overflow join at the baghouse plenum. The baghouse filters the

air through cloth bags to remove entrained ebonite dust. The bags are periodically shook by an automatic mechanism settling the dust to the bottom of the baghouse. The settled dust is also discharged to the bagging machine.

The separated materials are stockpiled and recovered by loaders when shipped. The recovered rock and debris is transported to the feed stockpile of the soils treatment plant to be processed with other soils.

Operations and Facility Description

For purposes of utilization of staff, facilities, material handling equipment, and utilities, it is assumed that the soils treatment plant, the battery casing treatment plant, and the ebonite treatment plant will be located adjacent to each other and share the same facility. The equipment and areas required to be covered (i.e., pugmill, classifiers, dryer, mill, bagging machine, baghouse, additive feed and mixing systems, additive storage, recycle components) will be located in a 18,000 square foot prefabricated building. The building will also include a sample preparation and storage room, bagged ebonite storage area, electrical room, operations office, change room, and toilets.

For the same purposes, it is assumed that the three plants will operate concurrently except for about three months at the start and three months at the end of operation. Because of the differences in the excavation phases for casings and soils, it is assumed that the battery casing plants will start operation three months before the soils plant, and the soils plant will run three months after the end of the casing plant operations. This will result in an estimated operating time of two-and-a-half years. The plants will operate eight hours per day, five days per week, and assuming an availability factor of 90 percent, the annual operating hours will be 1,875 per year. Plant through-put rates are calculated as follows:

Soils Treatment Plant

$39,497 \text{ tons} / 1875 \text{ hr.} \times 2 \text{ yrs} = 10.5 \text{ tons/hr}$

Battery Casings Treatment Plant

$75,786 \text{ tons} / 1875 \text{ hr.} \times 2 \text{ yrs} = 20.2 \text{ tons/hr}$

Ebonite Treatment Plant

$37,643 \text{ tons} / 1875 \text{ hr.} \times 2 \text{ yrs} = 10.0 \text{ tons/hr}$

It is assumed that the facility will operate with eight full-time and two part-time personnel. They will consist of the following:

<u>Quantity</u>	<u>Title</u>	<u>Hrs/Yr</u>
1	Operation Manager	2080
1	Sr. Process Engineer	2080
2	Process Operator	4160
1	Quality Control Technician	2080
2	Heavy Equipment Operators	4160
3	Laborers	6240
1	Safety Engineer (part time)	60
1	Clerk (part time)	1200

Maintenance would be done on an as-needed contract basis, which is assumed to be 800 hours per year. At the end of the two year operating period, the plant will be dismantled and removed, foundations demolished and disposed of, the plant area graded to the slope contours of the remainder site, and revegetated.

Surface Water Treatment

The surface water pollution problem is caused by runoff becoming contaminated by contact with contaminated soils and then discharging into East Doane Lake. The lake also is charged with contamination from groundwater sources. The lake is in a depression and receives runoff from the surrounding properties. East Doane Lake currently overflows during rainy periods and discharges to the Willamette River during heavy runoff periods. The overflow carries with it the contaminants from the lake.

To prevent the off-site discharge of these pollutants, the overflow will be permanently sealed. The site will be graded down away from the lake shoreline and the necessary swales and trenches constructed to prevent runoff entering the lake.

Testing Program

The end product of soil stabilization treatment will be tested for the appropriate physical and chemical characteristics. The design of the testing procedures will come after the pilot testing and selection of the particular stabilization technique. For the Gould site, the product will probably be a friable or soil-like material that will be subjected to physical tests typically used for soil compaction. Chemical containment properties of stabilized waste are difficult to predict from physical tests. The testing program would determine treated and untreated soil properties for porosity, permeability, wet and dry densities, particle size distribution, bulk properties, and durability.

(See Guide to the Disposal of Chemically Stabilized and Solidified Waste, EPA, 1982.)

Chemical leach testing of stabilized soil is recommended to predict its chemical stability. A great number of leach testing techniques are available. The major variables in the different procedures include the leaching solution characteristics, waste solution, time of contact, surface area of waste and agitation technique. A conservative testing procedure should be devised to test the chemical leaching potential of the stabilization method used.

Monitoring

The monitoring program will consist of airborne monitoring during the construction period and groundwater/surface water monitoring subsequently to determine the remedial conditions.

Ground-Water Monitoring: Ground-water monitoring will be performed once per year at eight sampling points to determine changes in concentration and plume migration. The wells that will be monitored are those located in the study area used for the remedial investigation. There are 18 wells at different locations and some having multiple completions providing 31 sampling points in the study area. They are RPW-1D, RPW-2D, RPW-3D, RPW-4D, RPW-5D, W-1D, W-2D, W-3D, W-3D2, W-40, W-6B, W-6D, W-6S, W-7D, W-7S, W-8D, W-9D, W-10D, W-11B, W-11D, W-11I, W-11S, W-120, W-12I, W-12S, W-15D, W-15I, W-15S, W-16D, W-16I, and W-16S. Of these points, sampling program will include RPW-4D, W-8D, W-9D, W-11S, W-11I, W-11D, W-3B, and W-6D. Points sampled in each period are designed to detect changes in concentration and plume migration.

Surface-Water Monitoring: East and West Doane Lakes will be monitored annually to determine changes in contamination levels in the lakes. A sampling program will be performed on a routine scheduled basis at the same time as groundwater. Sampling will be done by grab sampling methods at two locations in each lake.

The four locations will be in approximately the sediment sampling location utilized in the RI, i.e., SD-1, SD-2, SD-3, SD-4, SD-5, SD-6, SD-10, SD-11, SD-12, and SD-13. The samples would be analyzed for the lead content only.

Airborne Monitoring: Three high volume air monitors (HIVOL) are located on site. These will be supplemented with one more. The four will be located and installed just off-site on adjacent properties. To

monitor particulate migration, the four monitors will be sampled continually during the construction period. The filter media from these monitors will be analyzed for lead.

Monitoring Report: A report will be prepared annually after the monitoring activities are complete. The document will report the monitoring findings and outline changes and trends from the previous reporting periods.

Institutional Controls

The institutional controls pertinent to the Gould site include water wells restrictions, zoning and land use restrictions, site access restrictions, deed restrictions, and sale restrictions.

Each of these has been discussed in Section 4.1; those discussions apply to this alternative as well.

4.6 ALTERNATIVE 21

Soil Treatment/Disposal: Removal and Fixation of Subsurface Soils and Materials

Surface Treatment: Surface Capping and Revegetation

Battery Casing Treatment/Disposal: Battery Casing Removal and Disposal in an On-Site Tumbler

Surface Water: Isolation of East Doane Lake

Ground Water: Institutional Controls

Description

Surface soils and subsurface soils contaminated with levels greater than 3,000 ppm total lead (assumed EP Toxicity of 5 ppm) and the sediments and mat will be removed and treated with a fixation additive to bind the lead in the soils matrix. The battery casings will be removed and disposed of in RCRA-design tumbler constructed on site. These two actions will mitigate the airborne and sub-surface materials problems. The stabilized product from the soils process plant will be backfilled, graded, and compacted. A soil cap and vegetative cover will be placed over the backfill and tumbler cover to prevent weathering of stabilized soil, and subsequent remobilization of the metal components. East Doane Lake will be isolated and the site graded to prevent surface run-off entering the lake. The following describes the process and unit operations.

Earthmoving

The contaminated surface soils will be removed by bulldozers and motor scrapers, and stockpiled adjacent to the soils treatment facility. The subsurface-contaminated soil sediments and matte will be removed, using a dragline or backhoe for the mass excavation. Loaders and bulldozers will be used for cleanup. The bulldozer will also be used to break up the large pieces of sediments and matte. Surface and subsurface soil volumes with contamination above 3,000 ppm total lead, and the other waste materials are estimated to be the following:

	Volume (cu yd)	Mass (tons)
Surface Soils	3,370	4,344
Sub-surface Soils	13,650	17,593
Sediments	5,500	5,560
Matte	5,330	12,000
Battery Casings	80,000	75,786

Dump trucks will transfer the contaminated soils to a stockpile adjacent to the soils treatment facility. Soils less than 3,000 ppm removed for ease of access and slope stability will be stockpiled and later used as backfill and tumulus construction. Battery casings will be excavated by backhoe and motor scraper and stockpiled in a temporary storage area until the tumulus is constructed. Since the tumulus will almost cover the entire Gould site, it will be necessary to excavate all the battery casings and stockpile them on an adjacent site until the tumulus is constructed. A pad for temporary storage of battery casings will be constructed on the selected adjacent site. The pad will be constructed to meet environmental temporary storage standards in accordance with 40 CFR265.253/254, i.e., prevent run-on, contain and collect leachate. The pad will be 420 ft. x 820 ft. long, constructed to have a 1-foot high berm around the periphery and covered with a 40 mil. flexible membrane liner. The liner in turn will be covered with six inches of compacted fill to prevent liner damage by earthmoving equipment placing and retrieving battery casings. The pad will be sloped to one point where a lined pit will be located to collect leachate. A pump will be installed in the pit to pump out leachate to East Doane Lake. A loader will form the stockpile to a height of 12 ft. having side slope ratios of two horizontal to one vertical. The stockpile in this configuration will have 104,000 cubic yards, which is the estimated volume of the uncompacted battery casings.

A tumulus will be constructed onsite using natural uncontaminated material from the site and imported fill. The tumulus will be constructed to meet RCRA landfill requirements having a double liner with a leachate collection system and a multilayered cover. The tumulus will cover 85 percent of the Gould site outside of East Doane Lake. This will require that the Soils Treatment Facility operate first and then be dismantled before the tumulus can be constructed. The treated soils from the treatment facility will be used to backfill the battery casing excavation in the tumulus area.

The tumulus will be formed excavating a relatively flat area of 204,000 square feet, to a depth of 2.5 feet below existing grade. The sides of the excavation will be graded up to grade level at a slope ratio of 3 horizontal - 1 vertical. The peripheral banks will be built further at the same slope with excavated material to a total height of 5 feet from the base of the excavation. A trench for the base of the leachate collection system 5.5 feet deep x 10 feet wide will be excavated down the length of the tumulus in the center.

The tumulus will then be lined with 3 foot thick clay/soil liner. This will result in a configuration where the liner extends to the top of the berm, having a depth of 2 feet; the bottom will slope at 2 percent to the center leachate collection; and the leachate collection trench will be 2 feet wide by 2 1/2 feet deep. The clay tumulus dimensions will be 350 feet x 615 feet long inside at the top of the berm. The tumulus will then be lined with a double flexible membrane liner (FML) system comprised of two 45 mil HDPE liners with a geogrid between them. The lower liner (FML) will cover the entire tumulus area and follow the contours of the clay into the leachate collection trench. The trench will have a perforated pipe installed over its entire length and be filled with medium gravel. The pipe will extend into a leachate collection sump. The top liner (FML) and geogrid will cover the entire tumulus area and follow the contours of the bottom liner but will extend over the gravel in the trench. This will facilitate leachate collection, i.e., if a leak occurs in the top liner, it will pass into the geogrid which will transmit it to the trench, which in turn transmits it via the pipe to the leachate collection sump.

After filling, the compacted battery casings will be covered entirely with a FML liner which will be seal welded to the top lower liner. This will then be covered by 2 feet of clay (soil-bentonite) over its entire surface. These two low-permeability liners are to prevent surface water entering the tumulus. This will be covered with a

geotextile followed by a 2-foot layer of coarse gravel to deter burrowing animals from degrading the low permeability liners. The gravel layer would be covered with a geotextile, then along with other site areas, covered with 4 inches of top soil and hydro-seeded to provide a vegetative cover.

To prevent runoff into East Doane Lake, the site will be graded away from the shoreline. In addition to the earthmoving required on the Gould site, the northeast section of the American Steel Industries parking lot, which drains to the lake, will require modification. This will involve removing approximately 2,600 square feet of asphalt, installing a drain system discharging to the Gould site, and repaving the area.

The excavation of sub-surface battery casings and subsequent treatment will result in an extension of East Doane Lake. To prevent erosion, the excavation will be graveled at the shoreline and coarse gravel will be spread and graded for three feet above and below the water line.

To prevent excess airborne contaminant migration during surface and subsurface excavation, and material handling, dust control will be practiced as required.

The site will be graded to have swales and slopes to provide soil stability, drainage, and prevent run-on from adjacent areas. Topsoil will be imported to provide a 4-inch soil cap with a vegetative cover over the tumulus and other areas to prevent erosion.

Soils Treatment Facility

A treatment facility will be constructed at the site to treat contaminated sub-surface materials. The process is depicted on the flow diagram on Figure 4.5-1, and consists of a comminution system to reduce the materials to a relatively uniform size, and then pugmilling with an additive to bind the metals in the soils matrix. It is assumed for purposes of this study that the material size required for successful pugmilling is 100 percent minus 1/4 inch.

The crushing facility is comprised of two stages of crushing (jaw and cone), with a vibrating screen in close circuit with the cone crusher. The system is interconnected with belt conveyers. The sub-surface materials that are stockpiled adjacent to the treatment facility are fed in a hopper at the start of conveying system by loader. The subsurface materials in the hopper are drawn down by a vibrating feeder

at a rate of 10.5 tons per hour and discharged to a belt conveyer that feeds the jaw crusher.

The jaw crusher reduces all materials to 100% minus 1.5 inch and discharges it to a conveyer, feeding the vibrating screen. At the screen it is joined with the material from the cone crusher, and the minus 1/4 inch material is screened out. The screen oversize is directed to the cone crusher which reduces the material to 50 percent, minus 1/4 inch. The cone crusher product is transported by conveyer to join the jaw crusher material at the feed to the vibrating screen. The screen undersize (minus 1/4 inch) is transported to the pugmilling system feed hopper.

In the pugmilling section, the process commences at the feed hopper which provides a total surge capacity of one hour between the two systems. Stockpiling, retrieval, material handling, and circulating loads in the crushing circuit have now provided a uniform blend of feed material to the pugmill. The contents of the hopper are drawn down by vibrating feeder at a constant rate of 12 tons per hour. The feeder discharges the material to the pugmill where it is joined with binder additive and a predetermined amount of water. Dependent on the type of additive, it is fed to the pugmill either as a slurry or as a dry material by feeder. In the pugmill the additive is driven into the soils by paddle and a required amount of electromotive energy. The additive comprise of a cementitious fixative (cement, pozzolan, lime, clays); a reducing agent, and various proprietary chemicals. The actual additive composition and its ratio will be determined by pilot testing during the design phase. The pugmill discharges the stabilized soil to a belt conveyer which transports it to a stockpile from where it can be retrieved by loader for backfilling.

The equipment and areas required to be undercover, i.e., pugmill, additive feed and mixing systems, additive storage,; will be located in a 900 sq. ft. prefabricated building. The building will also include a sample preparation and storage room, electrical room, operations office, change room, and toilets.

It is assumed that the plant will operate for approximately two years. The plant will operate eight hours per day, five days per week, and assuming an availability factor of 90%, the annual operating hours will be 1,875 per year. Plant through-put rates will be as follows:

$$39,497 \text{ tons}/1875 \text{ hr.} \times 2 \text{ yrs} = 10.5 \text{ tons/hr}$$

It is assumed that the facility will operate with eight personnel. They will consist of the following:

<u>Quantity</u>	<u>Title</u>	<u>Hrs/Yr</u>
1	Operation Manager	2080
1	Sr. Process Engineer	2080
1	Process Operator	2080
1	Quality Control Technicial	2080
1	Heavy Equipment Operator	2080
1	Laborers	2080
1	Safety Engineer (part time)	60
1	Clerk (part time)	1000

Maintenance would be done on an as-needed contract basis, which is assumed to be 1,000 hours per year. At the end of the two year operating period, the plant will be dismantled and removed, foundations demolished and disposed of, the plant area graded to accommodate tumulus construction.

Battery Casings Treatment

The battery casing will be retrieved from the temporary stockpile by loader and motor scraper. They will be deposited in the tumulus by dump truck and motor scraper in eight inch lifts. Each lift will be compacted with a landfill compactor for a minimum of two passes to achieve a 95% compaction level. The finished dimensions of the tumulus will be 10 feet above the berm, 2 feet below with side slopes of 3:1 above and below. The nominal dimension inside at the top of the berm is 350 feet x 615 feet. This volume represents 84,210 cubic yards which is the in-situ volume compacted to 95% compaction level. The tumulus is then covered with a FML, clay, and vegetative cover as described in the earthmoving section.

A pump will be installed in the leachate collection sump. In the event of leachate appearing in the sump, the pump would be activated to pump out the leachate to a tanker truck that would transport it to a hazardous waste treatment plant.

Surface Water Treatment

The surface water pollution problem is caused by run-off contaminated by contact with contaminated soils and then discharging into East Doane Lake. The lake also is charged with contamination from groundwater sources. The lake is in a depression and receives runoff

from the surrounding properties. East Doane Lake has an overflow trench which allows discharge to the Willamette River during heavy runoff periods. The overflow carries with it the contaminants from the lake.

To prevent the off-site discharge of these pollutants, the overflow trench will be permanently sealed with a soil and clay barrier. The site will be graded down away from the lake shoreline and the necessary swales and trenches constructed to prevent run-off entering the lake.

Testing Program

The end product of soil stabilization treatment will be tested for the appropriate physical and chemical characteristics. The design of the testing procedures will come after the pilot testing and selection of the particular stabilization technique. For the Gould site, the product will probably be a friable or soil-like material that will be subjected to physical tests typically used for soil compaction. Chemical containment properties of stabilized waste are difficult to predict from physical tests. The testing program would determine treated and untreated soil properties for porosity, permeability, wet and dry densities, particle size distribution, bulk properties, and durability. (See Guide to the Disposal of Chemically Stabilized and Solidified Waste, EPA, 1982.)

Chemical leach testing of stabilized soil is required to predict its chemical stability. A number of leach testing techniques are available. The major variables in the different procedures include the leaching solution characteristics, waste-to-leaching solution, time of contact, surface area of waste and agitation technique. A conservative testing procedure should be devised to test the chemical leaching potential of the stabilization method used.

Monitoring

Tumulus: The leachate collection system of the disposal tumulus will be checked daily for the presence of liquids.

Ground-Water Monitoring: Groundwater monitoring will be performed twice per year. The four wells installed around the tumulus will be monitored every six months to detect leakage from the tumulus. Other wells on the site will be sampled in a flexible monitoring program. The program will sample four wells, twice per year, at the same time as the tumulus wells. The wells that will be monitored are those located in the study area used for the remedial investigation. There will be 17

wells available in the study area after tumulus construction, some having multiple completions providing 30 sampling points. They will be RPW-1D RPW-2D, RPW-3D, RPW-4D, RPW-5D, W-2D, W-3D, W-3D2, W-40, W-6B, W-6S, W-7D, W-7S, W-8D, W-9D, W-10D, W-11B W-11D, W-11I, W-12D, W-12I, W-12S, W-15D, W-15I, W-15S, W-16D, W-16I, and W-16S. The points sampled in each period may not be the same ones each time, but the sampling program will be designed to meet the objectives, i.e., changes in concentration and plume migration. The samples will be analyzed for lead. The monitoring program will last through the post-closure period of 30 years.

Surface Water Monitoring: East and West Doane Lakes will be monitored twice per year to determine changes in contaminant levels in the lake. A sampling program will be performed on a routine scheduled basis at the same time as air and groundwater. Sampling will be done by grab sampling methods at two locations in each lake. The four locations will be in approximately the sediment sampling location utilized in the RI, i.e., SD-1, SD-2, SD-3, SD-4, SD-5, SD-6, SD-10, SD-11, SD-12, and SD-13. The samples would be analyzed for the lead content only.

Airborne Monitoring: Three high volume air monitors (HIVOL) are located on site. These will be used to monitor particulate migration during the construction period. The filters will be changed weekly and analyzed. The filter media from these monitors will be analyzed for lead.

Monitoring Report: A report will be prepared after each monitoring event is complete. The document will report the monitoring findings and outline changes and trends from the previous reporting periods.

Institutional Controls

The institutional controls pertinent to the Gould site include water wells restrictions, zoning and land use restrictions, site access restrictions, deed restrictions, and sale restrictions. Each of these has been discussed in Section 4.1; those discussions apply to this alternative as well. As required under the Oregon Notice of Environmental Hazards Act and RCRA, notices would be placed on the deed and on another instrument, as appropriate, regarding restriction of property use.

4.7 ALTERNATIVE 25: ON-SITE DISPOSAL

Monitoring: Monitoring Wells; Leachate Collection System

Surface Treatment: Capping; Revegetation

Surface Water Treatment: Isolation of the East Doane Lake Remnant

Battery Casings Treatment/Disposal: Casings Removal for Treatment/Disposal; On-Site Vault Disposal

Soil, Sediment and Matte Treatment/Disposal: Soil, Sediment and Matte Removal for Treatment/Disposal; On-Site Vault Disposal

Institutional Controls: Site Access Restrictions; Land Use Restrictions; Deed Restrictions, Sale Restrictions

Description

Under this alternative, contaminated fill material would be disposed of in a regulated, onsite landfill or disposal vault. The landfilled material would include surface and subsurface soil and sediment contaminated to greater than 3,000 ppm total lead, as well as the battery casing fragments and matte. As discussed in Section 2.3.5, the depth to ground water at the site precludes construction of a regulated landfill or a disposal vault below grade. This alternative therefore involves constructing an above-ground tumulus on the site for containment of the fill.

Disposal of contaminated materials in a RCRA-approved tumulus would render them unavailable for transport in groundwater; and the landfill cap would eliminate airborne migration from the contained materials entirely. Site regrading would reduce the recharge of the East Doane Lake remnant by surface runoff, allowing the existing outlet of the lake to be plugged and eliminating the lake outlet as a path for contaminant migration off site.

Institutional controls would be used under this alternative to restrict public access to the landfilled contaminants. Periodic sampling and analysis of groundwater using the groundwater monitoring systems described under the No-Action Alternative, together with daily inspection of the leachate collection sump for liquid, will be used to confirm the integrity of the tumulus structure, and to verify that contaminants are prevented from migrating off site.

Excavation and Construction

The contaminated materials at the Gould site total slightly less than 3 million cubic feet (approximately 110,000 cubic yards) (see Table 3.2-2). Referring to Figure 2.3-6, and assuming the flat-topped disposal vault design on which this figure is based, this volume of material would require a tumulus approximately 15 feet high, occupying the entire site. Most of the site will thus form the base of the tumulus. Existing structures (the office building, the lunchroom, concrete foundations and pavement) will be demolished, in order to accommodate the tumulus.

Surface soils on site, contaminated soils and soils surmounting the battery casing fill on the Rhone-Poulenc property would be removed by bulldozers and motor scrapers and stockpiled on an adjacent site. During the Remedial Investigation, the soils surmounting the battery casing fill on the Rhone-Poulenc property could not be sampled. Before excavation, these soils would be tested for contamination. If the contaminant levels in these soils is less than 3000 ppm, they should be segregated from contaminated soils in order to minimize the amount of material that must be disposed of in the tumulus. Any other uncontaminated soil which is excavated to ease access to the fill materials or to provide slope stability should also be separated from contaminated materials. Uncontaminated soils excavated during remediation may be used for backfill or for berm construction.

The subsurface-contaminated soil and sediment and the battery casing fill and matte will be removed using a dragline or backhoe, with the cleanup performed by loaders or bulldozers. A bulldozer will be used to break up large pieces of sediment and matte to less than 8 in. diameter. Dump trucks will transport the excavated material to a stockpile. Since a tumulus will occupy almost the entire Gould site, excavated materials must be stored on an adjacent site until tumulus construction is complete. Temporary storage of excavated material must comply with 40 CFR 265.253 and 265.254, and must prevent run-on and contain and collect leachate. Under this alternative, a temporary storage pad 420 feet wide by 820 feet long and surrounded by a 1-foot high berm will be built. The pad will be covered with a 40-mil flexible membrane liner, and the liner will be blanketed with 6 inches of compacted fill to prevent liner damage. The pad will slope to a single lined pit, where leachate will be collected for discharge to the East Doane Lake remnant. A loader will pile the excavated fill on the pad to a height of approximately 12.5 feet, sloping it in a two to one horizontal to vertical ratio. A stockpile with these dimensions will hold a volume of

141,000 cubic yards, which is the estimated volume of the uncompacted fill.

Once the contaminated materials and the surface soils have been removed from the Gould property, the fill excavation will be backfilled. Prior to backfilling, the fill excavation must be dewatered so that the backfill may be suitably compacted. Water removed from any excavation at the site will probably contain elevated amounts of site contaminants due to mechanical agitation, and will therefore require treatment prior to discharge. Because of groundwater infiltration, the quantity of water will certainly be more than the volume of contaminated fill on the Gould property, or more than 20 million gallons. This volume is greater than can be reasonably discharged to the City of Portland sanitary sewer system, and so it must be discharged to a storm sewer or directly to the Willamette River. Discharge options will depend on treatment needs.

The base of the disposal vault will consist of a relatively flat area of 230,000 square feet, 2.5 feet below the existing grade elevation. The sides of the excavation will be sloped to grade at a ratio of three to one, horizontal to vertical. From grade, peripheral banks or berms will continue at this slope to a total height of 5 feet above the tumulus base. In the center of the excavation, a trench 5.5 feet deep by 10 feet wide will be constructed for the leachate collection system. The tumulus base will be lined by a uniform covering of soil/bentonite 3 feet thick, fashioned to slope downward by 2 percent to the leachate collection system trench. The lined leachate trench will be 2 feet side by 2.5 feet deep, and the tumulus inside dimensions, along the top of the berms, will be 350 feet wide by 833 feet long.

For leachate collection, a perforated pipe will be placed lengthwise in the lined leachate trench, extending into a leachate collection sump. A pump will be installed in the leachate collection sump. The pipe will be covered with medium gravel, to the top of the trench. The trench and the vault clay covering will be topped with a double flexible membrane liner system consisting of a geogrid sandwiched between two 45-mil HDPE liners. The double flexible membrane liner will cover the entire vault base, following the contours of the clay.

The contaminated fill will be retrieved from the stockpile by loader and motor scraper, and deposited into the vault by dump truck and motor scraper in 8-inch lifts. Each lift will be compacted using a landfill compactor, which will make a minimum of two passes to achieve a compaction level of 95 percent.

The completed tumulus will be covered with a flexible membrane liner and a clay cap. The cover liner will be seal welded to the outer edge of the base liner. The cover liner will be topped with two feet of soil/bentonite, which will cover the entire tumulus including the berms. The clay will be capped with a geotextile membrane, a 2-foot layer of coarse gravel, another geotextile membrane, and 4 inches of topsoil with a vegetative cover. The layer of gravel will prevent burrowing animals from degrading the deeper liners. The vegetative cover, which will be established over the entire site, will decrease erosion and improve the appearance of the site.

To prevent the accumulation of runoff in the East Doane Lake remnant, the site will be graded away from the shoreline. Regrading would be accomplished using a wheel tractor scraper and a grader. On the American Steel property, construction of a drainage system for directing runoff onto the Gould property would require 2,600 square feet of the asphalt parking lot be removed, then reinstalled. Runoff would be directed into a storm drain on the Gould property, and piped into the storm sewer system for discharge into the Willamette River. Without the recharge provided by surface runoff, the East Doane Lake remnant would no longer require an overflow to the Willamette River, and the existing overflow channel could be blocked.

Three HIVOLs were installed on site during the Remedial Investigation. During construction, these would be used to monitor particulate migration. HIVOL filters would be changed and analyzed weekly.

To prevent the dispersal of fugitive dust from the site, dust control will be practiced as required based on air monitoring results.

Operations and Facility Description

The finished tumulus will extend 10 feet above and two feet below the berm lip, with a side slope ratio of three to one both above and below. The nominal areal dimensions along the inside berm lip will be 350 feet by 833 feet. These dimensions constitute a volume of 114,200 cubic yards, which in the estimated in-situ volume compacted to the 95 percent compaction level.

Specific RCRA standards for hazardous waste liner systems include (Cope et al., 1984):

- ° Compatability of liner materials with waste material. Liner materials must also be able to withstand all expected physical

stresses, such as hydrostatic pressure, climatic variations, construction activities or fill compaction.

- Placement of the liner system on a stable foundation, to prevent liner failure due to settlement, compression, uplifting or warping.
- Installation that insures waste or leachate cannot contact surrounding soil.
- Inspection and monitoring during construction, and inspection for uniformity, damage and imperfections after construction completion.

RCRA requirements for new hazardous waste landfills stipulate that primary leachate collection and removal systems be placed immediately above the primary liner. Primary systems must maintain the leachate depth below 1 foot, and should withstand clogging, chemical attack, and any forces exerted either by the surmounting waste and final cover, or by construction equipment. Additional performance criteria are listed in the Handbook, Remedial Action at Waste Disposal Sites (Revised) (EPA, 1985). The secondary leachate system, which is placed between the liners to detect and remove any liquid which seeps into that space, is designed to similar standards.

Placement of the contaminated materials in a disposal facility on site would demand continued monitoring of the site to ascertain lasting protection of the environment. Site monitoring would involve daily inspection of the leachate collection system, and semi-annual sampling and analysis of ground water from wells downgradient of the site.

The leachate collection system would be checked daily for the presence of leachate. Ground water monitoring would be performed four times per year. Available ground-water monitoring wells are described under the No-Action Alternative, in Section 4.1. The four wells installed around the landfill vault will be monitored every six months to check for leakage from the vault. Other wells on site would be sampled in a flexible monitoring program. The program will sample four wells, twice per year. The samples will be taken in conjunction with monitoring of the vault wells.

Institutional Controls

As already discussed, the institutional controls appropriate to the Gould site include controls on water wells, zoning and land use restrictions, and site access restrictions. Maintenance of the present zoning would limit residential and public land use. In general, the site could not be developed or modified without assurance that appropriate actions would be taken to control the on-site contaminants.

The Water Resources Department of the State of Oregon is responsible for ground water use. A permit is not required for a domestic well producing less than 15,000 gal per day, or for an industrial well producing less than 5,000 gallons per day. For larger volumes than these, a water right application permit issued by the Water Resources Board would be required.

The Planning and Zoning Bureau of the City of Portland is responsible for land use designations. The Gould site is presently zoned heavy industrial. Continued industrial zoning will limit residential and public land use. The Permit Center of the City of Portland issues demolition and building permits based on applicable building codes and zoning ordinances, and after completion of an environmental checklist and a search of department records for files relating to environmental problems. The Permit Center employs representatives from various city departments, including planning and zoning, building, and environmental.

The site is fenced at present: this is adequate to prevent public access. The East Doane Lake remnant will be posted to warn intruders against drinking the water or swimming in the lake. As required under the Oregon Notice of Environmental Hazards Act and RCRA, notices would be placed on the deed and on another instrument, as appropriate, regarding restriction of property use.

(0.01 mg/l). The average lead concentration remaining in the equilibrated solutions in these four samples were 0.052 mg/l in sample W-7S-20', 0.004 mg/l in sample SD-3, 0.27 mg/l in sample S-9 and 0.072 mg/l in sample S-13.

The results indicate that resulting solution lead concentrations were relatively constant for a given sample, further indicating that there was no effect of initial solution lead concentration on the adsorption/desorption mechanisms. An example of this can be seen in the results for the S-9 sample. The spike lead concentration ranged from 0.0 to 2.0 mg/l but the equilibrated lead concentrations in the 5 solutions show no direct relationship to these increasing concentrations of lead in the initial spike solutions. In addition, the results for samples W-7S-20', S-9 and S-13 indicate that the samples leached lead into the 0.0 and 0.5 mg/l initial spike solutions (as indicated by a negative amount adsorbed in Table 5.3-2).

The results suggest that the controlling factor that determines the equilibrium solution lead concentration is the soil lead concentration and not the initial solution concentration. The results also indicate that the lead adsorption/desorption is probably due to surface adsorption and/or ion exchange mechanisms. The apparently anomalously low equilibrium solution lead concentration in sample SD-3 is probably due to the higher pH of the sediment (9.7) which may have influenced the adsorption/desorption mechanisms, possibly enhancing the pH controlled precipitation mechanism, thus lowering lead solubility in the solution.

The blank solution (no soil) results indicate that, in general, the concentrations of the parameters in the blank solutions remained constant throughout the test. The pH of the solutions dropped with increasing spike lead concentrations. This is probably due to the low pH of the spike solutions. There also appears to be an adsorptive loss of spike lead to the walls of the equilibration containers. This loss, approximately 0.5 mg/l, was constant throughout the range of spike solution concentrations and had little or no influence on the test results.

Comparison of the blank results to the sample results indicates that the sample soils leached most of the parameters other than lead into solution. Sample S-9 is the only sample indicating leaching of arsenic. All the samples leached the common element parameters (i.e., calcium, sodium etc.) into solution, as would be expected.

The R_d parameter was not calculated since lead was essentially removed from the solutions quantitatively. As described above (Section

TABLE 5.3-2
CALCULATION SUMMARY TABLE

	Initial Lead Spike Concentration (mg/l)	Corrected Lead Spike Concentration ¹ (Co) (mg/l)	Equilibrium Solution Lead Concentration (mg/l)	Amount of Lead Adsorbed on Soil (S) (mg/g)
W-6S-26'2	0.0	U0.01	U0.01	0.00
	0.5	0.04	U0.01	0.20
	1.0	0.43	U0.01	2.15
	1.5	0.92	U0.01	4.60
	2.0	1.40	U0.01	7.00
W-7S-20'	0.0	U0.01	0.06	-0.30
	0.5	0.04	0.05	-0.05
	1.0	0.43	0.05	1.90
	1.5	0.92	0.05	4.35
	2.0	1.40	0.05	6.75
S-9	0.0	U0.01	0.26	-1.30
	0.5	0.04	0.28	-1.20
	1.0	0.43	0.28	0.75
	1.5	0.92	0.24	3.40
	2.0	1.40	0.29	5.55
S-13	0.0	U0.01	0.06	-0.30
	0.5	0.04	0.07	-0.15
	1.0	0.43	0.06	1.85
	1.5	0.92	0.08	4.20
	2.0	1.40	0.09	6.55
SD-3	0.0	U0.01	U0.01	0.00
	0.5	0.04	0.02	0.10
	1.0	0.43	U0.01	2.15
	1.5	0.92	U0.01	4.60
	2.0	1.40	U0.01	7.00

(1) Corrected for adsorptive loss of 0.5 mg/l in blank.

(2) Representative of all samples with equilibrium solution lead concentrations below detection limit.

7.3.1), the plotted slope of the lead amount adsorbed from solution per gram of sample (S) versus the equilibrium lead solution concentration (C) would yield the R_d parameter. These values are presented below (Table 7.3-2). Since the equilibrium lead solution concentrations (C) are nearly constant for all samples, the slope of the line is vertical and the R_d parameter approaches infinity for all the samples. This result indicates that, under conditions simulated by this test, soils and sediments at the site have a high potential for lead adsorption.

5.3.4 Conclusions

The following conclusions are based on the results of the batch adsorption test:

1. Within the range of solution lead concentrations and compositions studied, the controlling factor in equilibrium solution lead concentration appears to be the total lead concentration in the soil and not the initial solution lead concentration.
2. The adsorptive capacity of the soils and sediments studied is 100 percent for lead when the total soil lead concentration is less than 800 mg/kg. Samples with higher total soil lead concentrations also have adsorptive capacities. Therefore, the results indicate that under the same conditions of this test, site soils and sediments probably have adsorptive capacities that lead to inhibited lead migration.

5.4 LEACH POTENTIAL TEST

5.4.1 Purpose and Scope

A third test performed during the RI was a leach potential test for the purpose of evaluating the potential for lead to leach from primary source material (battery casings and matte) and secondary source material (contaminated soils and sediment) into the ground water under varying conditions of pH. The effect of organics present in the ground water on the potential for lead leaching was also evaluated.

The five sample types used in the leach potential test consisted of battery casing, matte, surface soil, subsurface soil, and sediment samples. One sample of each representative type of lead-containing material (lead concentration >100 mg/kg) was used in the test. When there was not enough of a particular sample, a composite sample was

used. The leach solutions consisted of pH-adjusted tap water that encompassed the 2.8 - 12.5 pH range of the ground water measured at the site. The hardness and sulfate concentrations of the tap water were adjusted with magnesium and calcium sulfate salts to levels representative of the site water. Ground water obtained from the site with potentially high concentrations of organics was used as well. The leach solutions were analyzed for pH, dissolved lead, and arsenic after an equilibration period of 24 hours.

5.4.2 Procedure

The leach potential test was conducted following the procedures described below:

1. The five sample types used in the leach test were analyzed for pH, percent solids, total lead and total arsenic before the test began.
2. Each sample type was divided into four portions, each weighing 80 grams. For each of the five material types, the four portions were placed into four clean, acid-washed bottles and labeled 1 through 4. A duplicate set of bottles was prepared for one of the sample types and an additional set of bottles was prepared as a blank (no soil added). A total number of 28 bottles were prepared.
3. Four leach solutions were prepared for the leach test. Three of the solutions were prepared with tap water. Calcium and magnesium sulfate salts were added to bring the hardness of the tap water to a level representative of the site water (500 mg/l). The pH of these three solutions was adjusted with sulfuric acid and sodium hydroxide to desired levels of 2.8, 6.0 and 12.0, respectively. Representative site water with high organics concentrations, collected immediately before the leach test began, comprised the fourth leach solution.
4. The four bottles for each of the five sample types, duplicate, and blank samples were filled with the solutions described above. The bottles were filled as follows:

<u>Bottle Number</u>	<u>Solution</u>
1	2.8 pH
2	6.0 pH
3	12.5 pH
4	Organics

5. The sample bottles were equilibrated for 24 hours at constant temperature with an end-over-end tumbler. After that time, the leach solutions were filtered through 0.45 micrometer (um) filters and split into two portions, A and B.
6. Filtrate portion A was analyzed for pH and dissolved arsenic. Filtrate portion B was acidified to pH <2 with nitric acid and analyzed for dissolved lead.

5.4.3 Results

The results of the leach potential test are presented in Table 5.4-1. The results indicate that leachable lead was detected from all five of the sample material types under test conditions. The leachable lead concentration varied depending on the sample material and on the initial leach solution pH.

The battery casing sample results indicate that the high pH leach solution resulted in the largest concentration of leachable lead (660 mg/l). The results also indicate that there was a small increase in leachable lead concentration in the low pH solution (0.25 mg/l) compared to the moderate pH solution (0.15 mg/l). The results for the high organic leach solution (0.75 mg/l) indicate a small increase in leachable lead concentration compared to the moderate pH solution, which has a comparable solution pH. The high leachable lead concentration measured in the high pH leach solution is probably the result of solubilized lead hydroxides that precipitate at lower pH. Leachable arsenic was detected above the detection limit (0.005 mg/l) in the high organic leach solution (0.027 mg/l) and in the high pH solution (0.007 mg/l).

The sediment sample results indicate that the leachable lead concentrations were approximately the same for each of the four leach solutions, with the high organic solution result (0.18 mg/l) indicating a slight increase over the moderate pH leach solution (0.12 mg/l). The arsenic analyses indicate that the high pH solution resulted in the largest concentration of leachable arsenic (1.6 mg/l). The results also

TABLE 5.4-1

LEACH POTENTIAL TEST RESULTS

Sample Material	Initial Leach Solution pH/TOC	Final Leach Solution pH	Leach Solution Lead Concentration (mg/l)	Leach Solution Arsenic Concentration (mg/l)
Blank	2.8/LOW	2.8	U0.05	U0.005
	6.0/LOW	6.1	U0.05	U0.005
	12.5/LOW	12.3	0.08	U0.005
	6.5/HIGH	6.5	0.11	U0.005
Battery Casing	2.8/LOW	6.8	0.25	U0.005
	6.0/LOW	6.9	0.15	U0.005
	12.5/LOW	12.2	660	0.007
	6.5/HIGH	6.6	0.75	0.027
Sediment	2.8/LOW	6.8	0.13	0.087
	6.0/LOW	6.9	0.12	0.059
	12.5/LOW	11.7	0.13	1.6
	6.5/HIGH	6.6	0.18	0.32
Matte	2.8/LOW	5.8	6.8	U0.005
	6.0/LOW	5.8	9	0.005
	12.5/LOW	6.3	0.23	U0.005
	6.5/HIGH	5.8	5.2	0.008
Subsurface Soil	2.8/LOW	12.3	0.31	U0.005
	6.0/LOW	12.4	0.36	U0.005
	12.5/LOW	12.5	0.46	U0.005
	6.5/HIGH	12.1	0.18	U0.005
Surface Soil	2.8/LOW	5.8	3.1	0.007
	DUPLICATE	5.8	2.7	U0.005
	6.0/LOW	5.9	0.44	U0.005
	DUPLICATE	6.0	0.48	U0.005
	12.5/LOW	11.9	7.9	0.72
	DUPLICATE	11.8	6.3	0.72
	6.5/HIGH	6.2	0.7	0.007
	DUPLICATE	6.3	0.61	U0.005

indicate that there was a slight increase in leachable arsenic in the low pH solution (0.087 mg/l) compared to the moderate pH solution (0.059 mg/l). The results for the high organic leach solution (0.32 mg/l) indicate a moderate increase in leachable arsenic concentration compared to the moderate pH solution.

The matte sample results indicate that the leachable lead concentrations in the low pH (6.8 mg/l), moderate pH (9.0 mg/l) and high organic (5.2 mg/l) leach solutions were relatively the same. The high pH leach solution result (0.23 mg/l) is significantly lower, possibly due to adsorption of lead onto iron oxides generated by the high initial pH of the solution (the matte material has very high concentrations of iron). Leachable arsenic results were relatively the same for all four leach solutions, ranging from less than the detection limit (0.005 mg/l) to 0.008 mg/l in the high organic leach solution.

The subsurface soil results indicate that leachable lead concentrations were relatively the same for the low, moderate and high pH solutions (0.31, 0.36, and 0.46, respectively). The high organic leach solution result was slightly lower (0.18 mg/l). There was no detectable arsenic in any of the four leach solutions. The equilibrated pH in all four solutions was greater than 12.0. This is probably due to the very high pH of the soils used for the test.

The surface soil sample test was conducted in duplicate. The results for the sample and the duplicate sample indicate good agreement, with an average percent difference of less than ± 20 percent. The results indicate that the high pH solution resulted in the largest leachable lead concentration (7.9 mg/l). The results for the low pH leach solution (3.1 mg/l) indicate a significant increase in leachable lead compared to the moderate pH solution (0.48 mg/l). The high organic solution result (0.70 mg/l) indicates a slight increase over the moderate pH solution. Arsenic concentrations were at or below the detection limit (0.005 mg/l) in the low and moderate pH and high organic leach solutions. The leachable arsenic concentration in the high pH leach solution was 0.72 mg/l.

5.4.4 Conclusions

The following conclusions are based on the results of the leach potential test:

1. Solutions with high initial pH (greater than 11) increase the leachable lead and arsenic concentrations, except where possible scavaging/adsorption by iron oxides may occur.

2. The leachability of lead is apparently enhanced at low pH compared to moderate pH. If the conditions simulated during the test are representative of the site conditions, then lower pH water would have a greater potential for mobilizing lead at the site.
3. Although high organic leach solutions indicated slightly higher leachable lead concentrations in some samples, there is no apparent significant leachable lead enhancement attributable to the organic concentrations used in this test. Therefore, if the high organic solution composition is representative of site water, then organics would probably have no significant effect on lead mobilization at the site.

5.5 SOIL SOLIDIFICATION STUDY

Weston Services Inc. of West Chester, Pennsylvania was retained by NL Industries, Inc. and Gould Inc. to assess the potential application of soil solidification for stabilization of lead-contaminated secondary source materials (soils and sediments) from the Gould site. To conduct the test, representative samples of surface soils and East Doane Lake sediments were shipped to Weston and tested with a number of different solidification agents. The report of the Weston engineering study, contained in Appendix B, is summarized below.

5.5.1 Technical Approach

Representative soil samples from the Gould site and sediment samples from East Doane Lake were sent to Weston for an assessment of stabilization as an appropriate remedial action. Initial examination of the materials included determination of density, liquid content, TCLP for lead, and physical consistency. Bench-scale stabilization tests were then performed to assess the potential for admixing reagents to create a solidified and stabilized mass. Reagents chosen for testing include the following:

- Portland cement
- Cement kiln dust
- Flyash
- Lime kiln dust
- Commercial grade lime
- Cement kiln dust/sodium carbonate.

Reagents were added incrementally by weight at particular liquid contents to achieve homogeneous mixtures. During the curing period,

each admixture's index properties (liquid content, density and physical consistency) were carefully observed. In addition, bearing capacity tests were conducted to examine the mixture's curing characteristics as a function of time. Methods and materials used to complete the bench-scale tests are outline in the Weston report.

Following curing, the potential leachability of the stabilized admixtures was evaluated through performance of EPA's TCLP leaching procedures for analysis of lead. Successful application of the stablization technique was determined to be an admixture TCLP test result below 5.0 mg/l.

In addition to the TCLP analyses, Weston examined the effects of two other leaching procedures in measuring lead contaminant levels. The first was the EP Toxicity testing procedure, which is intended to simulate essentially a "worst-case" in-situ condition of pH = 5. The second was an ASTM leaching test procedure successfully used by Weston on similar projects. The procedure utilizes a neutral pH leaching with distilled water rather than acid to simulate environmental conditions. This procedure is performed at the pH of the sample, unlike the TCLP and EP Toxicity procedures. For purposes of reporting the results of the test, however, Weston relied on the TCLP procedure.

5.5.2 Results and Discussion

Table 5.5-1 summarizes the laboratory test data for the TCLP analyses of various admixtures. The results show that admixtures of Portland cement, cement kiln dust, and lime kiln dust with the soil and sediment at specific increments improved the consistency, structural stability and reduced the leachability of the contaminated materials.

Depending on the actual moisture content encountered during full-scale implementation, a cement kiln dust or lime kiln dust reagent addition, when mixed with the lead-contaminated material, may provide a cost-effective alternative. The cost of Portland cement, on the other hand, would likely be prohibitive and probably offers no significant advantages over the other reagents.

While stabilization may be a feasible alternative to apply to soils and sediments at the Gould site, a field-scale pilot demonstration would be necessary to confirm the results of these stabilization tests. In particular, the variability of soil moistures, density and composition at the Gould site is great. The best reagent to apply, the proper percentages of materials in the admixture, and indeed the feasibility of

TABLE 5.5-1
TLCP LEACH TEST RESULTS

<u>MIX I.D. NO.</u>	<u>SAMPLE MATRIX</u>	<u>REAGENT DESCRIPTION</u>	<u>LEAD LEACHATE LEVEL mg/L</u>	<u>TEST RESULT</u>
Initial	Soil	N/A	710	Fail
Initial	Sediment	N/A	24	Fail
1B	Soil	20% Portland Cement	ND*	Pass
2	Soil	20% Cement Kiln Dust (CKD)	3.5	Pass
3	Soil	20% Fly Ash	503	Fail
4	Soil	20% Lime Kiln Dust (LKD)	1.0	Pass
6B	Soil	20% CKD, 0.22 Sodium Carbonate	36.6	Fail
8	Sediment	50% Cement Kiln Dust	ND	Pass
10	Sediment	50% Lime Kiln Dust	1.0	Pass
12	Soil	10% CKD, 1.4% Sodium Carbonate	503	Fail
13	Soil	10% Cement Kiln Dust	336	Fail
14	Soil	30% Cement Kiln Dust	1.37	Pass
15	Soil	10% CKD, 3.7 % Sodium Carbonate	69.4	Fail

*ND: Sample was analyzed, but not detected.

the technology, cannot be finally determined without comprehensive testing of materials at representative site conditions.

5.6 MA INDUSTRIES, INC.

In July, 1987 a test was conducted on equipment manufactured by MA Industries, Inc. of Peachtree City, Georgia. The equipment chosen for the test is currently in operation at Ace Battery Company of Indianapolis, Indiana. Ace Battery uses the equipment to break and crush whole batteries, then to separate the battery materials into component parts of metallic lead, plastic, hard rubber (ebonite), and lead oxide.

The purpose of the test was to determine the effectiveness of the equipment in a proposed site application as part of Alternative 10. The application would consist of building a plant on the Gould site to separate the mixed primary source materials into components of metallic lead, plastic, ebonite, and lead oxide/dirt/mud. The primary process equipment would consist of the separation equipment sold by MA Industries.

5.6.1 Technical Approach

To conduct the test, approximately twenty tons of mixed materials were collected from different areas of the site and transported to Indianapolis for processing. The methods used to excavate, transport, and sample the materials are outlined in the engineering study work plan in Appendix B, along with information on the MA Industries process equipment. The results of the study consist of a series of sequential laboratory analyses also contained in Appendix B (see Laucks lab reports numbers 4793, 5499, and 5954). A summary of the results is presented in Section 5.6.2.

Five material streams emerge from the MA Industries separation equipment. The five streams are (1) metallic lead; (2) hard rubber (ebonite); (3) plastic; (4) lead oxide/mud; (5) lead oxide/mud. Note that two of the streams contain lead oxide/mud mixtures; this is a function of the arrangement of the classifiers in the process arrangement, which can vary depending on the size of the equipment.

The goal of the analytical testing of materials emergent from the equipment was to determine the lead content of the various separated streams, which is a critically important consideration for recycle of the materials. The lead content is especially important for the plastic

and the ebonite, which must be low in lead for successful recycle. In order to determine the nature of the lead remaining in the plastic and ebonite after separation, a series of sequential laboratory analyses was performed. The series consisted of total lead and TCLP lead analyses on the plastic and ebonite as received from the separation equipment, then after two different kinds of washes: (1) a wash with deionized water; (2) a wash with hydrochloric acid followed by a "quench" wash with deionized water.

5.6.2 Results and Discussion

The total lead and total solids content of the metallic lead, plastic, ebonite, and lead oxide/mud streams is summarized in Table 5.6-1. Also shown is the TCLP result for plastic and ebonite before any washes. Two samples were run for each; the first sample represented material primarily from the Gould property, while the second sample represented material primarily from the Rhone-Poulenc property. In the table, the lab results for the two lead oxide/mud streams are averaged for presentation. For additional detail, refer to Appendix B.

TABLE 5.6-1

SOURCE MATERIALS AFTER SEPARATION

Material	Total Lead (% dry wt.)	TCLP Lead (mg/l)	Total Solids (%)
<u>Gould Property Sample:</u>			
Metallic Lead	93.7	--	100.0
Plastic	0.28	76	98.1
Ebonite	0.74	200	93.9
Lead Oxide	15.8	--	70.4
<u>Rhone-Poulenc Property Sample:</u>			
Metallic Lead	50.1	--	100.0
Plastic	0.39	140	90.0
Ebonite	1.4	210	93.2
Lead Oxide	28.8	--	69.2

The analytical results on the separated streams show that plastic and ebonite both fail the TCLP lead test, and the degree of failure is not particularly dependent upon the location of the material; plastic and ebonite from the Gould property fail nearly as badly as plastic and ebonite from the Rhone-Poulenc property.

Also of interest is the percentage of lead in the metallic lead stream, which is one measure of efficiency of separation. In the metallic lead stream received from the separated material on the Gould property, about 94 percent of the stream was lead; the remainder was non-lead metal and other debris. But in the metallic lead stream received from the separated material on the Rhone-Poulenc property, only about 50 percent of the material was lead. Since the percentage of metallic lead is much lower on the Rhone-Poulenc property (less than 0.1 percent) than on the Gould property (about 1-1.5 percent), the efficiency of separation clearly is shown to decrease as the percentage of lead in the source material decreases.

As discussed in the technical approach, plastic and ebonite were subjected to two washes after separation. The effect of the washes is summarized in Table 5.6-2.

TABLE 5.6-2

RESULTS OF PLASTIC AND EBONITE TREATMENTS

Material	Treatment	Total Lead (mg/kg)	TCLP Lead (mg/l)	Total Solids (%)
Plastic ⁽¹⁾	No Wash	3350	108	94.0
Plastic	DI Wash ⁽²⁾	3350	112	89.8
Plastic	Acid Wash/ DI Wash	2260	72	94.2
Ebonite ⁽¹⁾	No Wash	10700	205	93.5
Ebonite	DI Wash	5050	205	86.4
Ebonite	Acid Wash/ DI Wash	16050 ⁽³⁾	195	92.0

(1) Total lead, TCLP lead, and Total solids are averages of sample results from Gould property and Rhone-Poulenc property.

(2) DI Wash = Deionized water wash.

(3) Average of 2 values: 3100 mg/kg and 29,000 mg/kg.

The results in Table 5.6-2 show that a deionized water wash has no observable effect on the total lead content of either the plastic or the ebonite. This result indicates that the lead is not surficial on either the plastic or the ebonite; rather it would appear to be interstitial and/or bound into the solid matrix of the material. The results following a short wash with hydrochloric acid show that the lead was not significantly removed from the ebonite, and only a minor fraction was removed from the plastic. The results indicated that much more vigorous treatment of both separated materials is required before recycle can be seriously considered.

In a normal operating mode, the MA Industries equipment processes whole battery casings, not the mixture of materials represented by the Gould site source materials. Certain problems were observed with the equipment that would need to be compensated for in design of a field-scale unit. Two problems are noteworthy here:

1. A key consideration is that materials must be able to be crushed in the hammermill if they are to be successfully processed. For the Gould site, the practical consideration is that extensive and continuous labor would be required to hand-pick all rock, rock-like matte pieces, and other debris (wood, concrete chunks, auto body metal, etc.) from the feed stream to the separation equipment.
2. A second consideration is that extremely heavy foaming, which greatly complicated the separation process, was noted during the processing of materials that contained significant fractions of dirt. Since this is the condition for nearly all of the primary source material, the problem would need to be rectified in the design phase.

As a final note, another user of the MA Industries equipment has reported high water usage of the system, which would complicate the already-high expected maintenance requirements.

5.7 POLY-CYCLE INDUSTRIES, INC.

Following the completion of the MA Industries test, a second separation test was performed on equipment manufactured by Poly-Cycle Industries, Inc. of Jacksonville, Texas. The equipment used for the test is currently in operation at Poly-Cycle's Jacksonville plant. The purpose of the test was much the same as the test performed in Indianapolis. In addition to examining the performance of Poly-Cycle's

separation equipment, however, Poly-Cycle expressed interest in determining the marketability of the separated components. Poly-Cycle has had some success in finding applications for recycled ebonite, primarily as an additive to drilling muds used in the oil exploration industry.

5.7.1 Technical Approach

To conduct the test, approximately twenty tons of mixed materials were again collected from different areas of the site and transported to Jacksonville, Texas for processing. The methods used to excavate, transport, process, and sample the materials are outlined in the engineering study work plan in Appendix B. The results of the study consist again of a series of laboratory analyses also contained in Appendix B. A summary of the results is presented below.

Poly-Cycle's equipment has the same purpose as MA Industries', but the operation is somewhat different. Whereas five material streams emerge from the MA Industries separation equipment, only three emerge from Poly-Cycle's equipment: (1) plastic; (2) lead oxide/mud; (3) metallic lead/ebonite combined. After the combined metallic lead/ebonite stream emerges from the separation equipment, Poly-Cycle air-dries the metallic lead/ebonite, then passes it through an additional piece of equipment (called a "Green Machine") for separation of metallic lead from ebonite. After such separation, the ebonite is ground to a particle size suitable for subsequent use, primarily in the oil exploration industry.

As with the MA Industries equipment, the goal of the analytical testing of materials emergent from Poly-Cycle's equipment was to determine the lead content of the various separated streams. Because of the time frame of testing relative to submittal of this Feasibility Study, the only testing accomplished to date has been analysis of the lead oxide/mud for total lead, analysis of the plastic for total lead and TCLP lead, analysis of the separated metallic lead and ebonite streams for dry weight percent lead, and analysis of the ebonite ground to various particle sizes for total lead and TCLP lead.

5.7.2 Results and Discussion

The results of the analyses are shown in Table 5.7-1. Additional details are presented in Appendix B. The results show that the plastic and ebonite again fail the TCLP test. The results on plastic are somewhat more promising than those from the Ace Battery test; TCLP lead in the plastic is 13 mg/l with no additional washing. However, the

results for ebonite are even worse than those from Ace Battery. A key piece of information is the result for metallic lead in the separated, unground ebonite: the analytical laboratory reported 0.4%, or 4000 mg/kg, metallic lead in the ebonite prior to grinding. This result would indicate that the degree of separation of metallic lead from ebonite was wholly inadequate, because no matter what the subsequent treatment of the ebonite, the lowest total lead result, without another physical separation step, would be 4,000 mg/kg.

TABLE 5.7-1

TEST RESULTS FROM POLY-CYCLE INDUSTRIES EQUIPMENT

Material	Total Lead	TCLP Lead (mg/l)	Total Solids (%)
Plastic	310 mg/kg	13	94.1
Lead Oxide	52.0%	--	80.1
Metallic Lead	99.5%	--	----
Ebonite (unground)	0.4%	--	----
Ebonite (coarse)	1,100 mg/kg	200	96.2
Ebonite (medium)	40,000 mg/kg	99	97.8
Ebonite (fine)	5,900 mg/kg	170	96.9

Indeed, following the completion of the Poly-Cycle test, representatives of Poly-Cycle determined that the high lead content in the ebonite could be due, in part, to improper settings and/or operation of the "Green Machine" used for separation of metallic lead from ebonite. To determine the possible impact of this variable on the overall process, a second test of the Poly-Cycle equipment is planned. The excavation and transportation of material from the Gould site to Jacksonville, Texas is scheduled, at this writing, to take place on November 12-13, 1987. Processing of the material is scheduled to take during the week of November 16-20, 1987. Samples from the test will be submitted for laboratory analysis.

As a result, no firm conclusion can be drawn about the feasibility of the Poly-Cycle process at this point. The marketing arrangements of Poly-Cycle seem promising, but NL Industries and Gould Inc., from corporate viewpoints, will not accept the liability that attends recycle of materials with such high lead content.

5.8 UNITED SCRAP LEAD

During the conduct of the FS, contacts were made with other industry sources to determine the state of efforts made to address site conditions that are similar to those at the Gould site. The effort made at the United Scrap Lead site is noteworthy.

United Scrap Lead is a Superfund site near the City of Troy, Ohio. From 1946 to 1980 the operators of the facility processed discarded batteries to reclaim the lead components for resale. Throughout the operational history, United Scrap Lead used the various waste components from the normal operations as fill material on the site. Those wastes included rubber and plastic battery casings, metallic lead, and spent acid. In September 1984, the site was placed on the NPL under CERCLA.

During conduct of the RI, it was determined that approximately 55,000 cubic yards of waste battery casings and associated materials are present at the site. There is extensive soil contamination as well. The primary health threat is direct contact with the lead-contaminated materials.

A treatability study was conducted (see Appendix B) to determine the amenability of the primary source materials to reduction in lead content for subsequent recycle. Of direct relevance to the Gould site is the method used during the treatability study to reduce the lead content of the rubber casings. The investigators used samples of mixed casings containing approximately 70 percent rubber, 15 percent lead oxide/mud, 3 percent metallic lead, and 12 percent moisture. The samples were then tumbled in a ball mill with various wash solutions to determine the ability of the solutions to reduce the lead content of the rubber casing material. The results of the washes, reported in Table 5 of the treatability study in Appendix B, are reproduced in Table 5.8-1.

TABLE 5.8-1

RESULTS OF UNITED SCRAP LEAD BALL MILL WASHING

Wash Solution	Post-Wash Rubber Casing Lead Content, ppm	Remarks
Ammonium acetate (4%) + acetic acid (3.5%)	2,520	Readily filtrable
Tetra-Na EDTA (5%) or Di-Na EDTA (5%)	1,563	Extremely difficult to filter
Tap Water	2,500	Readily filtrable

Following the ball mill washing, the rubber casings were subjected to a sonic cleaning and soaking. The results of this treatment, reported in Table 6 of the treatability study in Appendix B, are reproduced in Table 5.8-2.

TABLE 5.8-2

RESULTS OF SONIC CLEANING AND SOAKING OF BATTERY CASINGS

Method	Lead Remaining (mg/kg)	EP Toxicity Lead (mg/l)
1-15 min. sonic cleaning	540	44
3-30 min. sonic cleaning	370	--
6 day soak	76	15.5
3 day soak in 5% EDTA + 15 min. sonic cleaning	30	5

The investigators conclude that the various wash, soak, and clean steps show promise for treatment of the casing material. The investigators also conclude that much more work needs to be done to determine the relevance of bench-scale lab results to a field-scale process unit. In particular, the long retention times noted in the wash steps would pose two very significant problems: 1) size, location, and operation of tankage needed to achieve these retention times; and 2) handling of the leachate water after the leach/wash step is complete.

Perhaps the most important conclusion to draw from this study, as well as all of the studies performed at the Gould site, is that although there appears to be promise for any of several treatment applications, the state of the technology is developmental and much work needs to be done to transfer the technology to a feasible approach to remediation of sites and recycle of contaminated primary source materials.

5.9 GRANITE CITY

A CERCLA site at Granite City, Illinois has inorganic metals contamination problems, with lead-contaminated source materials, including ebonite, remaining on-site. Data available from the site show the results of lead in ebonite following an engineering test to separate source materials. At the Granite City site, separation equipment manufactured by Cal West was used for the study.

A somewhat sketchy report on the separation tests shows that following component separation, three analyses were performed to determine the total lead content of the ebonite at the site (see Appendix B). The three data points for the ebonite reportedly show a total lead content ranging from 105,000 mg/kg to 286,000 mg/kg. The average of the data is 193,000 mg/kg total lead in the ebonite.

Without more information about the parameters of the test, it is difficult to draw strong conclusions. However, the data represents results achieved on a third type of manufactured equipment for source material separation, and the reported results are certainly not encouraging.

5.10 SUMMARY

Perhaps the strongest conclusion to draw from all of the studies reported in this section is that the state of technology for treatment applications at the Gould site and similar sites is developmental. Particular problems demonstrate the fact that the separation equipment

4.8 TREATMENT OF WATER

[Reserved]

5.0 ENGINEERING STUDIES

During the conduct of the FS, several engineering studies were performed to determine the technical feasibility of treating and recycling source materials at the Gould site. Other studies were performed prior to the beginning of the FS. A summary of the results of studies performed follows. Reports and laboratory analyses for studies performed during the RI/FS are contained in Appendix B.

5.1 ALCHEM WESTERN

AlChem Western, Inc. began setting up equipment on the Gould site in late 1983 for the purpose of washing, separating, and reclaiming plastic fragments and lead oxide. Battery casing fragments were dredged from the East Doane Lake remnant on the northeast portion of the Gould site and stockpiled along the shoreline. After a brief period of activity, Alchem Western suspended operations because of mechanical problems (Moore 1986). Although most of the Alchem Western equipment has been removed, some still remains on the Gould site. The surface debris piles dredged from the lake remnant still remain near the lake remnant. Some of the debris piles have been processed; others have not. No written report for, or data about, the test have been found.

5.2 BATTERY CASING COATING TEST

5.2.1 Purpose

During the RI, a test was performed for the purpose of assing the potential for three different coating formulations to minimize the leaching of lead from the casing material. The test material consisted of a composite of 12 battery casing samples collected as part of the battery casing sampling program (Section 3.2.3). Three coating materials were evaluated: (1) a proprietary lead control compound (K-20 Lead-In-Soil Control Mixture); (2) a non-proprietary chemical coating compound (sodium silicate); and, (3) an epoxy paint. Aliquots of the composite battery casing sample were coated with onẽ of the coating materials and each coated sample was extracted and analyzed for lead according to EP Toxicity test procedures.

5.2.2 Procedure

The composite battery casing sample was prepared by combining representative 80-gram portions of 12 individual battery casing samples. The twelve representative portions were taken from samples that had

already been prepared for analysis by EP Toxicity procedures (i.e., particle size reduced to pass the appropriate screen size) during the battery casing sampling program. The composited sample was divided into four equal samples and the individual samples were screened again with a No. 14 sieve mesh screen to remove particles that would be lost during the coating procedure. Forty grams of each sample retained on the screen were used in the coating test. The four screened samples were labeled A, B, C, and D. The D sample was held for future analysis; the A, B, and C samples were treated as follows:

- A. The proprietary coating solution K-20 ICS/LS was delivered to the analytical laboratory in two parts, part A and B. The solutions were mixed at a 10:1 ratio by mixing 250 milliliters (mls) of part A with 25 ml of part B. The 40-gram battery casing sample labeled A was added to the mixed coating solution, stirred for one minute and then strained. The coated material was spread out on mixing paper and dried for 26 hours. The dried, coated material was extracted and analyzed as described below.
- B. The sodium silicate solution was obtained by the analytical laboratory and was identified as Banco (TM), Anderson Laboratories, Inc. No. 68330, 4 liters sodium silicate 41° Be solution (water glass-technical). The 40-gram battery casing sample labeled B was added to a beaker containing 200 ml of the sodium silicate solution and stirred for one minute. The coated material was spread out on mixing paper and dried for 26 hours. The dried, coated material was extracted and analyzed as described below.
- C. The epoxy spray paint was delivered to the analytical laboratory and was identified as Zynolyte epoxy spray paint, clear 0537 (net wt. 13 oz.). The 40-gram battery casing sample labeled C was placed in a plastic bag filled with air and epoxy spray mist. The bag was sealed and shaken to lightly coat all surfaces of the material. The casing material was then spread onto mixing paper and sprayed with additional paint. A total of approximately 4 oz. of spray paint mixture was used. The coated material was dried for 26 hours and the dried, coated material was extracted and analyzed as described below.

The three coated battery casing samples were extracted by EP Toxicity procedure EPA method 1310, without the grinding and/or screening steps. The 40-gram samples were extracted with 640 mls of deionized

water. The pH was adjusted with the required volume of acetic acid during the extraction to adjust the pH of the samples to 5 ± 0.2 . The extracts were analyzed for lead by EPA method 6010 (ICP).

5.2.3 Results

The results of the battery casing coating test are presented in Table 5.2-1. The laboratory data report has been submitted previously (Dames & Moore, 1987).

TABLE 5.2-1

BATTERY CASING COATING TEST RESULTS

Sample Designation	Extract Lead Concentration (mg/l)
A	290
B	520
C	30

The results of the battery casing coating test indicate that none of the three coating formulations tested reduced the leachable lead concentration below the accepted standard concentration established to identify a waste as hazardous or non-hazardous. (Maximum contamination level [MCL] for lead in the EP Toxicity test is 5 mg/l.) The epoxy spray had the best overall reduction in leachable lead with an extract lead concentration of 30 mg/l. However, this concentration is still six times higher than the MCL.

5.2.4 Conclusions

The following conclusions are based on the results of the battery casing coating test:

1. The coating formulations tested were not effective in reducing the leachable lead concentration below acceptable levels; and
2. The epoxy resin coating resulted in the largest reduction in leachable lead concentration. Larger quantities and/or additional coatings of epoxy paint may further reduce the leachable lead concentration. However, the logistical difficulties of

application to large volumes of battery casing materials, the large quantities of coating spray necessary, and the potential toxic or hazardous nature of the coated material makes this an impractical treatment alternative.

5.3 BATCH ADSORPTION TEST

5.3.1 Purpose and Scope

Also during the RI a batch adsorption test was performed to evaluate the soil/water interactions between representative site soil samples and dissolved lead in ground water and soil particles. These soil/water interactions include adsorption and desorption interactions between dissolved lead in ground water and soil particles. Adsorption results in removal of dissolved lead from the ground water by the soil material, thereby reducing the ground-water lead concentration and mobility. Desorption results in a release of lead associated with the soil material into the ground water, thereby increasing the ground-water lead concentration. Emphasis was placed on the effect of these interactions with respect to the dissolved lead retardation potential by the soils (adsorption). The procedure has been extensively used by soil scientists and geochemists concerned with determining retardation parameters suitable for modeling contaminant transport (Relyea, et al. 1980; Pavlik and Runnells 1984).

The batch adsorption test consisted of equilibrating representative samples of different site soil types with representative site water containing different concentrations of dissolved lead. Twelve soil samples including six surface soil, four subsurface soil and two sediment samples, were collected for this test during their respective sampling programs. The collection procedures are described in Appendix A. Representative site ground water was collected immediately before the test was initiated. The site water was spiked with four different dissolved lead concentrations ranging from 0.0 to 2.0 mg/l. The samples were equilibrated for 24 hours, then filtered and analyzed for dissolved lead and other water quality parameters.

The results of the batch adsorption test are used to determine the R_d parameter, a measure of the partitioning of lead between soil and water. The R_d parameter for lead is defined and calculated as follows:

$$R_d = \frac{(\text{mass of Pb adsorbed per gram of soil})}{(\text{mass of Pb in solution after equilibration period})}$$

The R_d parameter is determined by plotting an adsorption isotherm for the data collected in the batch test. This defines the partitioning

relationship for Pb between the solid phase and the ground-water solution. For each sample type, the following calculation is made:

$$S = (C_o - C) V/M$$

where

S = amount of lead adsorbed on soil
C_o = initial concentration of Pb in solution
C = final concentration of Pb in solution after the equilibration period
V = total volume of fluid
M = total mass of soil

A plot of S versus C determines the partitioning function for each sample type. The slope of this partitioning function is the lead R_d for each sample type.

The value of the R_d parameter rests in its ability to describe the partitioning of a dissolved contaminant between the soil and the ground water in contact with the soil. Generally, the partitioning relationship observed in the adsorption isotherm is linear in the range of concentrations observed under field conditions. Therefore, the R_d can be directly used in the advection-dispersion equation in the development of models for predicting the rate of contaminant movement in ground water.

In predictive models, R_d is used to calculate a retardation factor defined in the retardation equation as follows:

$$R = 1 + (p R_d/n)$$

where

p = bulk density of porous medium
n = porosity of porous medium
R_d = retardation coefficient or distribution coefficient
R = retardation factor

The retardation factor is used to calculate the velocity of the dissolved contaminant movement relative to the velocity of ground water.

5.3.2 Procedure

The batch adsorption test was conducted following the procedures described below:

1. Twelve representative soil samples were screened so that only materials passing a 2-millimeter (mm) screen were used. Each of the 12 samples were split into five subsamples weighing

80 grams each. The five subsamples were placed into clean, acid-washed bottles and labeled 1 through 5.

2. Five solutions were made with representative ground water. One solution was not spiked and therefore had a dissolved lead concentration representative of the collected site water. The remaining four solutions were spiked so that resulting dissolved lead concentrations were 0.5, 1.0, 1.5 and 2.0 mg/l. The representative site water (no spike) was placed in bottle 1 and the four spike solutions were placed in bottles 2 through 5. The volume of solution placed in each bottle was 400 ml.
3. One set of five bottles containing the same 400-ml solutions used in step (2) but with no soil were also prepared. These bottles were prepared as the blank or control samples to monitor the changes in concentrations not due to soil/water interactions.
4. The 60 bottles containing soil and water and the five bottles with only water were equilibrated for 24 hours at constant temperature.
5. After the 24-hour equilibration period, the bottles were centrifuged and the decanted solution from each bottle was filtered through a 0.45 micron filter. The filtrate was split into two portions, A and B.
6. Filtrate portion A was analyzed for pH, specific conductance, alkalinity, sulfate, and chloride.
7. Filtrate portion B was acidified with nitric acid to pH <2 and the acidified sample was analyzed for the dissolved constituents lead, arsenic, sodium, potassium, calcium, magnesium, iron, and zinc.

5.3.3 Results

The results of the batch adsorption test are presented below (Table 5.3-1). The four samples, one subsurface sample (W-7S-20'), one sediment sample (SD-3) and two surface soil samples (S-9 and S-13), all had total lead concentrations in the soil greater than 800 mg/kg. The results indicate that four of the samples had dissolved lead concentrations remaining in the equilibrated solutions above the detection limit

TABLE 5.3-1

BATCH ADSORPTION TEST RESULTS

SAMPLE NUMBER	Soil Pb Concen- tration (mg/kg)	Pb Spike Concen- tration (mg/l)	pH	Pb (mg/l)	As (mg/l)	Zn (mg/l)	Fe (mg/l)	Mn (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	SO ₄ (mg/l)	Alkalinity (as CaCO ₃) (mg/l)	EC (umhos/cm)
BLANK	---	0.0	6.1	0.01	0.005	0.006	0.01	1.6	0.2	4	0.2	U1	2	6	26
		0.5	5.9	0.04	0.005	0.110	0.01	2.4	0.3	0.01	0.1	U1	1	6	16
		1.0	4.2	0.43	0.005	0.140	0.01	2.3	0.4	0.01	0.1	U1	1	U1	37
		1.5	3.8	0.92	0.005	0.160	0.09	2.4	0.4	0.01	0.1	U1	U1	U1	72
		2.0	3.5	1.40	0.005	0.170	0.01	2.5	0.4	0.01	0.01	U1	U1	U1	110
		Average	4.7	0.56	0	0.117	0.02	2.2	0.3	0.8	0.1	0	0.8	2.4	52.2
W-6S-26'	16	0.0	7.0	0.01	0.005	0.084	0.03	39	8.4	88	47	20	10	490	1000
		0.5	7.2	0.01	0.005	0.072	0.01	39	8.4	88	45	18	10	480	990
		1.0	7.1	0.01	0.005	0.069	0.01	40	8.4	96	47	18	10	440	980
		1.5	7.2	0.01	0.005	0.077	0.01	39	8.4	93	46	18	10	450	990
		2.0	7.0	0.01	0.005	0.069	0.01	40	8.4	94	46	19	9	450	990
		Average	7.1	0.00	0	0.074	0.01	39	8.4	92	46	18.6	10	462	990
W-7S-20'	820	0.0	6.2	0.06	0.005	0.580	0.05	63	7.2	69	28	16	180	250	860
		0.5	6.2	0.05	0.005	0.550	0.17	64	7.2	68	28	17	180	240	870
		1.0	6.2	0.05	0.005	0.550	0.06	64	7.2	68	27	16	180	230	880
		1.5	6.2	0.05	0.005	0.560	0.08	66	7.2	58	28	16	170	230	880
		2.0	6.3	0.05	0.005	0.550	0.15	67	7.2	62	28	16	180	230	870
		Average	6.2	0.05	0	0.558	0.10	65	7.2	65	28	16.2	178	236	872
B-6-21'	74	0.0	6.9	0.01	0.005	0.086	0.24	62	9.6	90	51	16	120	480	1200
		0.5	7.0	0.01	0.005	0.083	0.13	68	9.4	92	49	16	110	480	1200
		1.0	7.0	0.01	0.005	0.075	0.26	68	9.6	91	50	17	120	470	1200
		1.5	7.1	0.01	0.005	0.071	0.21	70	9.6	90	50	16	120	470	1200
		2.0	7.1	0.01	0.005	0.079	0.29	70	9.6	89	48	16	120	450	1200
		Average	7.0	0.00	0	0.079	0.23	68	9.6	90	50	16.2	118	470	1200
B-8-32'	41	0.0	6.7	0.01	0.005	0.140	0.23	69	8.0	54	31	53	56	340	940
		0.5	6.7	0.01	0.005	0.140	0.03	69	8.0	54	30	57	60	320	920
		1.0	6.6	0.01	0.005	0.140	0.06	69	9.0	55	30	62	52	320	940
		1.5	6.7	0.01	0.005	0.140	0.25	69	8.0	55	31	48	48	320	940
		2.0	6.7	0.01	0.005	0.140	0.12	70	9.0	56	31	48	49	320	940
		Average	6.7	0.00	0	0.140	0.14	69	8.0	55	31	53.6	53	324	936
S-1	500	0.0	6.5	0.01	0.005	0.200	0.56	29	7.8	54	23	12	10	310	660
		0.5	6.4	0.01	0.005	0.190	0.15	28	7.6	53	22	11	9	310	630
		1.0	6.5	0.01	0.005	0.200	0.11	29	7.6	53	22	9	7	290	630
		1.5	6.5	0.01	0.005	0.180	0.21	29	7.6	56	23	12	10	290	630
		2.0	6.5	0.01	0.005	0.200	0.18	29	7.6	56	23	11	10	290	640
		Average	6.5	0.00	0	0.194	0.24	29	7.6	54	23	11	9	298	638

TABLE 5.3-1

BATCH ADSORPTION TEST RESULTS

SAMPLE NUMBER	Soil Pb Concen- tration (mg/kg)	Pb Spike Concen- tration (mg/l)	pH	Pb (mg/l)	As (mg/l)	Zn (mg/l)	Fe (mg/l)	Na (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	SO4 (mg/l)	Alkalinity (as CaCO3) (mg/l)	EC (uamhos/cm)
S-9	20000	0.0	6.3	0.26	0.017	0.610	0.07	30	15	190	30	18	400	150	1300
		0.5	6.4	0.28	0.013	0.670	0.29	29	15	180	30	18	430	140	1300
		1.0	6.3	0.28	0.012	0.630	0.12	30	15	190	30	19	390	140	1300
		1.5	6.4	0.24	0.012	0.590	0.12	30	15	190	30	19	420	140	1400
		2.0	6.3	0.29	0.011	0.720	0.15	30	15	200	29	18	400	140	1300
		Average	6.3	0.27	0.013	0.644	0.15	30	15	190	30	18.4	408	142	1320
S-13	1400	0.0	6.7	0.06	0.005	0.140	0.12	28	9.8	69	26	11	31	330	710
		0.5	6.6	0.07	0.005	0.150	0.14	28	9.8	72	27	11	27	330	710
		1.0	6.7	0.06	0.005	0.160	0.11	28	9.8	71	28	11	25	330	710
		1.5	6.6	0.08	0.005	0.130	0.09	27	10	71	28	10	24	330	720
		2.0	6.7	0.09	0.005	0.140	0.11	28	10	73	28	11	28	330	730
		Average	6.7	0.07	0	0.144	0.11	28	9.9	71	27	10.8	27	330	716
S-37	16	0.0	7.4	0.01	0.005	0.088	0.02	31	3.2	82	60	12	9	510	920
		0.5	7.4	0.01	0.005	0.078	0.08	31	3.0	76	56	11	9	500	920
		1.0	7.4	0.01	0.005	0.089	0.08	31	3.0	76	54	11	9	500	910
		1.5	7.4	0.01	0.005	0.081	0.15	30	3.0	81	54	11	9	480	920
		2.0	7.4	0.01	0.005	0.081	0.05	29	3.2	77	54	11	9	480	920
		Average	7.4	0.00	0	0.085	0.08	30	3.1	78	56	11.2	9	494	918
S-45	20	0.0	7.5	0.01	0.005	0.089	0.02	29	3.8	77	66	16	9	510	980
		0.5	7.6	0.01	0.005	0.100	0.02	30	3.8	78	64	12	9	510	970
		1.0	7.5	0.01	0.005	0.081	0.07	29	3.6	77	64	12	8	500	990
		1.5	7.5	0.01	0.005	0.070	0.01	29	3.6	76	66	12	10	500	990
		2.0	7.5	0.01	0.005	0.074	0.01	30	3.6	74	64	12	9	500	990
		Average	7.5	0.00	0	0.083	0.03	29	3.7	76	65	12.8	9	504	984
S-57	45	0.0	6.5	0.01	0.005	0.130	0.09	28	5.6	46	19	12	9	250	540
		0.5	6.4	0.01	0.005	0.140	0.11	28	5.6	46	18	12	9	250	540
		1.0	6.4	0.01	0.005	0.130	0.11	28	5.6	45	19	12	9	250	550
		1.5	6.4	0.01	0.005	0.140	0.15	28	5.8	44	19	14	10	250	550
		2.0	6.4	0.01	0.005	0.140	0.16	28	5.6	46	18	12	9	240	550
		Average	6.4	0.00	0	0.136	0.12	28	5.6	45	19	12.4	9	248	546

TABLE 5.3-1

BATCH ADSORPTION TEST RESULTS

SAMPLE NUMBER	Soil Pb Concen- tration (mg/kg)	Pb Spike Concen- tration (mg/l)	pH											Alkalinity (as CaCO ₃) (mg/l)	EC (umhos/cm)
				Pb (mg/l)	As (mg/l)	Zn (mg/l)	Fe (mg/l)	Na (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	SO ₄ (mg/l)		
SD-7	26	0.0	7.0	00.01	00.005	0.110	0.04	41	6.8	72	38	13	39	410	840
		0.5	7.0	00.01	00.005	0.100	0.03	40	6.8	73	40	13	39	410	840
		1.0	7.0	00.01	00.005	0.110	0.06	41	6.8	71	39	12	40	410	850
		1.5	6.9	00.01	00.005	0.100	0.04	41	6.8	73	39	13	43	400	860
		2.0	6.9	00.01	00.005	0.110	0.03	41	6.8	74	40	13	40	400	860
		Average	7.0	0.00	0	0.106	0.04	41	6.8	73	39	12.8	40	406	850
SD-3	160	0.0	7.4	00.01	00.005	0.084	0.10	36	7.4	120	28	14	34	490	1000
		0.5	7.5	0.02	00.005	0.200	00.01	37	7.4	110	27	16	36	500	1100
		1.0	7.3	00.01	00.005	0.085	00.01	36	7.4	110	27	15	37	490	1000
		1.5	7.3	00.01	00.005	0.140	0.07	36	7.4	110	27	16	35	490	1000
		2.0	7.3	00.01	00.005	0.087	0.02	36	7.4	110	28	15	36	480	1100
		Average	7.4	0.00	0	0.119	0.04	36	7.4	112	27	15.2	36	490	1040

is generally designed to handle whole batteries, rather than the mix of materials that remain at the Gould site. Technology for field-scale removal of lead from ebonite is only at the research stage at this point.

Much work remains to be completed to allow transfer of the separation technology studied during the FS to a feasible approach for remediation of sites and recycle of contaminated source materials. The equipment and methods to accomplish the task are simply not available today.

6.0 DETAILED EVALUATION OF THE FINAL REMEDIAL ALTERNATIVES

This section presents a detailed evaluation of each of the final remedial action alternatives which were retained through the screening process described in Section 3.0. Section 4.0 provided a detailed description of each of these alternatives, emphasizing key features such as the goal of the alternative; the associated remedial technologies, including available information on performance and reliability; conceptual design features of major facilities, operating equipment and construction machinery; engineering, safety, institutional, environmental and public health considerations that may influence the effectiveness of the alternative; and operation, maintenance and monitoring requirements. The detailed evaluation that follows discusses the cost-effectiveness of each of the final remedial alternatives in terms of their technical, institutional, public health and environmental attributes.

Guidance for conducting a detailed evaluation for alternatives under the NCP has been revised as part of SARA. Revised guidance was received in a July 31, 1987 letter from EPA Region 10. According to NCP and revised guidance, the detailed evaluation of the final remedial action alternatives must include an analysis of effectiveness, implementability, and cost factors for each of the alternatives. Such analysis must include:

- ° Assessment of the effectiveness in preventing, mitigating or minimizing hazards to and furnishing adequate protection of the public health and welfare and the environment;
- ° Evaluating of any adverse environmental effects, means of mitigating these effects, and the costs associated with utilizing these means;
- ° Examination of the reliability of each alternative;
- ° The ability of each alternative to conform with ARARs;
- ° Assessment of the amount of reduction of contaminant toxicity, mobility or volume;
- ° Assessment of the alternative's implementability, including technical feasibility, administrative feasibility, and availability; and

- ° Detailed estimation of costs, including operation and maintenance costs, the distribution of costs over time, and the sensitivity of costs to changes in interest rates.

6.1 DESCRIPTION OF EVALUATION CRITERIA

The criteria used for the detailed evaluation of the final remedial action alternatives are summarized in Table 6.1-1. The technical evaluation addresses the implementability, reliability and constructability of the alternatives and their associated technologies, as well as their performance and safety. The institutional evaluation assesses the compliance of the alternatives with current EPA policy, with applicable and relevant standards, with guidance and advisories for Superfund remedial action sites. It also discusses the policies of other involved agencies, as well as the concerns of the community. The endangerment assessment evaluation of public health and environmental effects appraises the ability of the alternatives to limit the presence of hazardous materials in the environment and their effectiveness in avoiding the unacceptable threats to public health established by the Risk Assessment. Overall environmental effects are estimated by comparing the beneficial results with the adverse consequences of the alternatives. The cost evaluation includes capital costs and operating and maintenance costs for a 30-year operating period. For comparison, the costs of the alternatives are presented at their present worth values.

In order to assess the relative merits of the final remedial alternatives in terms of the above criteria, a relative score of low, moderate, or high was assigned to each alternative for each criterion. A low rating indicates that treatments under the alternative are not consistent with the intent of the criteria, and that the alternative does not meet or exceed the remedial objectives. A moderate rating indicates that treatments under the alternative are only partially consistent with the criteria, but that the alternative does meet an appreciable number of the remedial objectives. A high rating indicates that treatments under the alternative are consistent with the intent of the criteria, and that the alternative meets or exceeds the remedial objectives.

TABLE 6.1-1

CRITERIA FOR THE DETAILED EVALUATION OF THE ALTERNATIVES

Effectiveness
Endangerment Assessment
Reliability
Conformance to ARARs
Reduction in Toxicity, Mobility, or Volume
Implementability
Technical Feasibility
Constructability
Performance
Safety
Time Required
Administrative Feasibility
Permitting Requirements
Community Concerns
Institutional Requirements
Availability
Cost
Capital Cost
Operation and Maintenance Cost
Present Worth
Sensitivity Analysis

In subsections 6.1.1 through 6.1.3, the evaluation criteria are described to clarify how these relative ratings will be applied. In Sections 6.2 through 6.8 each of the alternatives is evaluated with respect to the factors. In Section 6.9, the ratings for each of the categories are combined in summary tables to provide an overall rating for each of the alternatives.

6.1.1 Effectiveness

Effectiveness refers to the degree of prevention or mitigation of substantial danger to the public health and welfare or to the environment which is provided by the alternative. Alternatives which completely immobilize, destroy or recycle hazardous waste rate the highest on the scale of performance. Useful life refers to the length of time that the alternative retains its effectiveness.

6.1.1.1 Endangerment Assessment

6.1.1.1.1 Introduction

The endangerment assessment provided in Appendix A was performed to evaluate the potential for human health and environmental effects based on exposure to site contaminants. The primary contaminant identified was lead, for which inhalation and ingestion can result in systemic, noncarcinogenic health effects. A screening level review of arsenic and cadmium was performed, resulting in the decision not to include these contaminants in the detailed risk assessment based on relatively low levels of arsenic contamination and relatively low exposure and health risks associated with cadmium.

Present in primary source materials, soils, and the sediments in East Doane Lake, lead can be released to the environment through dust generation by wind and vehicles; surface runoff into surface water, and soil leaching into groundwater. Soils, air, and surface water were found to contain elevated levels of lead. The potential human exposure pathways for these release mechanisms at the Gould site are inhalation of dust, incidental ingestion of soils, and incidental ingestion of surface water by children who might swim in East Doane Lake. Ground water was considered to be an incomplete pathway because dissolved contaminants have not passed the site boundaries and the area is served by the Portland city water system.

6.1.1.1.2 Methods

Exposure scenarios were developed to estimate the potential human exposure under the No-Action Alternative, including on-site workers and onsite and offsite residents for inhalation and incidental soils ingestion. Exposure estimates for ingestion examined cases for best and upper bound estimates of contaminants as well as base and high dose cases of ingested soils. For the surface water pathway, calculations were made of the exposure for children swimming in East Doane lake, assuming incidental ingestion of water.

The analysis began by deriving concentration levels for lead in air and soils. The ISC model (see Appendix A) was used to derive air contaminant levels for lead onsite and offsite (at the fenceline). Best and upper bound estimates for soil levels also were calculated based on sample results from the Remedial Investigation. The upper bound soil estimate consisted of the maximum concentration of lead oxide in waste piles, while the best estimate was a subarea-weighted average for the study area.

Calculations of residual incremental exposures after completion of remedial activities were based on designating some areas as exclusionary and replacing soil concentrations to reflect the expected effects of remedial actions. The highest value and subarea-weighted average were again used.

Calculations of exposures during remedial activities assumed that onsite workers would be protected through a health and safety program along with the use of personal protective equipment where warranted. An offsite worker (at the fenceline) scenario was developed to examine the inhalation exposure from fugitive dust. An emissions inventory was developed to determine dust and lead sources from equipment and activities.

Average daily exposures were calculated for the scenarios and compared with acceptable chronic intake levels as specified in the Superfund Public Health Evaluation Manual for noncarcinogenic health effects. The analysis also compared the lead level in East Doane Lake and the Willamette River with the standards for drinking water and Oregon Water Quality Standards to examine potential effects on the environment.

6.1.1.2 Reliability

Reliability is the capacity for performing at a designated level without extensive operating or maintenance support. The assessment of operating and maintenance needs must consider the availability of labor and materials, and the frequency and complexity of routine maintenance; and must appraise the probability of component failure. Technologies which require frequent maintenance rate lower on the scale of reliability. Reliability may in part be estimated from demonstrated performance at similar sites.

6.1.1.3 Conformance to ARARs

Each of the alternatives is evaluated for its ability to meet ARARs which are established for the site. In addition to contaminant-specific ARARs, other ARARs that are location-specific or action-specific are evaluated where appropriate.

SARA authorizes EPA to select an alternative that does not meet ARARs for on-site actions if any one of six specified waivers can be applied to the proposed onsite action.

6.1.1.4 Reduction in Toxicity, Mobility, or Volume

The degree to which each alternative employs treatment that reduces toxicity, mobility, or volume of contaminants is addressed. Factors considered include treatment processes used, degree of permanence in treatment, and a consideration of process residuals including the persistence, toxicity, mobility, and propensity to bioaccumulate of the residuals.

6.1.2 Implementability

Implementability is the relative ease of installation or construction of the alternative. The relative implementability of an alternative also reflects the amount of time needed to achieve a given level of response.

6.1.2.1 Technical Feasibility

The technical feasibility of the final candidate alternatives is evaluated based on the relative ease of installation (constructability), performance, safety, and time.

6.1.2.1.1 Constructability

Constructability of an alternative is affected by the nature of the technologies employed, by site conditions, and by conditions external to the site. For a specific technology, the availability of necessary construction materials or of specially trained personnel will affect the constructability of an alternative. Site conditions which may affect constructability include the location of utilities, the depth to the water table, the properties of subsurface materials, and site location. External conditions which may affect constructability include the need for special permits or agreements or the availability of off-site disposal.

6.1.2.1.2 Performance

Performance is the ability to meet standards or requirements. Performance of a remedial action alternative is measured by its effectiveness and by its useful life.

6.1.2.1.3 Safety

Safety of neighboring communities, of those employed in implementing remediation, and of the environment is evaluated in terms of both short-term and long-term hazards. Short-term safety hazards are those that arise during the implementation of the alternative. Short-term hazards to be considered include fire, explosion and exposure to hazardous substances. Long-term hazards are those that persist throughout the life cycle of the alternative.

6.1.2.1.4 Time Required

Two time factors arise in the consideration of technical feasibility: 1) the time required to implement the proposed remediation, and 2) the time required to fully attain the objectives of the proposed remediation.

6.1.2.2 Administrative Feasibility

Permitting requirements, community concerns and institutional requirements each affect the administrative feasibility of an alternative, which is an estimate of the degree of procedural difficulty a remedial alternative will face in being implemented.

6.1.2.2.1 Permitting Requirements

SARA allows remediation efforts to bypass the federal, state, and local permitting process for the portion of remedial actions conducted entirely on site, in order to prevent delays in implementation of clean-up actions. Compliance with the intent of permits is nonetheless an objective of site remedial actions. For those alternatives that include handling and disposal of hazardous wastes, RCRA requirements must be met. For example, if the waste is transported off-site, it must meet the transportation requirements of RCRA. If waste is found to be hazardous, and the intent is to dispose of it in an onsite landfill, the landfill will have to be RCRA-permittable. This would include meeting RCRA design criteria and 30 year post closure monitoring requirements.

Additionally, where heavy construction is being done and process facilities are constructed, building permits would be required from the City of Portland Permit Center.

Specific permitting requirements for the final candidates alternatives are described in the subsequent evaluation of alternatives.

6.1.2.2.2 Community Concerns

A full assessment of community attitudes toward the alternatives cannot be made until the formal public comment period on the proposed plan and RI/FS has been completed. In the FS, evaluation of community concerns is dependent upon the historic level of public involvement with the site, a gauge of media interest in the site, and a knowledge of general public attitudes in the area of the site.

6.1.2.2.3 Institutional Requirements

The evaluation for the factor of institutional requirements also includes a discussion of the effectiveness of various institutional controls that may be initiated or requested by either the owner or regulatory agencies.

6.1.2.3 Availability

The factor of availability refers to the developmental status of equipment and specialists required to operate it. Also considered is the capacity and location of needed treatment, storage, and disposal services.

6.1.3 Cost Analysis

The cost analysis consists of the three steps as specified in the EPA Guidance on Feasibility Studies under CERCLA (EPA 1985a): estimation of costs, present worth analysis, and sensitivity analysis. The development of conceptual level cost estimates is based on the conceptual engineering performed for each remedial alternative as presented in Section 4.0. The cost estimates presented in this section are expressed in 1987 dollars and include capital costs and annual operation and maintenance costs. The cost estimates are accurate to within -30 percent and +50 percent of the final project cost as per the Guidance Document.

6.1.3.1 Capital Costs

All important facilities/equipment and construction features identified in the conceptual design were quantified and used in estimating the capital costs. The total capital costs were developed into two major categories: direct costs and indirect costs. The major direct capital costs include such items as site preparation, construction, well drilling, equipment, buildings, and service costs. Materials, equipment, and installation costs for each remedial alternative were derived from literature sources, vendor quotes, and previous studies. An ite-

mized breakdown of the capital cost estimates for the remedial alternatives is presented in Appendix C by major cost components.

The indirect capital costs include engineering, design, administration and inspection expenses, contingency allowances, preparation of permit-equivalent information, and in some cases, shakedown. The assumptions used for indirect capital cost estimates are as follows:

- ° Contingency allowances: For this level of effort, contingencies are usually up to 30 percent of Total Direct Construction Cost, depending on how well the technologies involved are established and the uncertainties involved in implementation. Considering the development stage of the technologies and the uncertainties involved in their implementation, a nominal 30 percent was used for Alternatives 1, 2A, 2B and 8, which have reasonably well-defined requirements. A nominal 50 percent was used for Alternatives 10; 40 percent was used for Alternatives 21 and 25. These three alternatives have greater uncertainties relating to equipment availability and amount of material to be handled.
- ° Engineering and design expenses: 12 percent of Total Direct Construction Cost.
- ° Administration and inspection expenses: 5 percent of Total Direct Construction Cost.
- ° Permit-Related Costs: 2 percent of Total Direct Construction Cost, where land use and buildings are used.
- ° Shakedown Costs: 2 percent of Total Direct Construction Cost, added if a process facility was involved.

6.1.3.2 Annual Operation and Maintenance Costs

The annual operations costs for each unit operation were developed based on manpower requirements, estimated power demand, material and chemical quantities, and sampling and analysis requirements. Unit cost rates provided by vendors were used to estimate some of these operation costs. The annual maintenance costs were developed based on equipment replacement schedules, servicing requirements, and general maintenance activities.

An itemized breakdown of the annual operation and maintenance cost estimates for the remedial alternatives is presented in Appendix C.

6.1.3.3 Present Worth

Present worth analysis is used to evaluate the capital and operation and maintenance costs that occur over different time periods of the remedial alternatives by discounting all future costs to a common monetary basis, the present worth. This allows the costs of the various alternatives to be compared on the basis of a single total cost figure representing the amount of money, that, if invested in the base year and expended as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. The present worth of an alternative is computed according to the following formula:

$$PW = (PWF) (O + M) + TCC$$

Where:

PW = present worth

PWF = present worth factor for an interest rate of 10 percent and a period of 30 years (9.427)

O = annual operation cost

M = annual maintenance cost

TCC = total capital cost

The PWF is a function of the interest rate and the time period. Interest rates of 5, 10, 12 and 15 percent and a time period of 15 years were used to develop the present worth according to the EPA Guidance Document (EPA 1985a). It should be noted that no inflation factor has been considered in the operation and maintenance cost. Table 6.9-4 presents a summary of the present worth of each of the remedial alternatives including its capital cost and the present worth of its operation and maintenance cost.

6.1.3.4 Sensitivity Analysis

A sensitivity analysis may be conducted to assess the effect that assumptions associated with the design, implementation, operation, interest rate, and effective life can have on the estimated costs of the alternatives. These assumptions depend on the accuracy of the data developed during the remedial investigation and on prediction of the future behavior of the remedial technology and are subject to varying degrees of uncertainty. The sensitivity of the costs to these uncertainties can be evaluated by varying these assumptions and noting the effect on estimated costs.

It can be noted that the cost differences of many of the final alternatives is not large due to the similar or common components. To adjust one of the parameters would produce similar changes in the cost of all the similar alternatives. As a result, a sensitivity analysis

Sensitivity analyses of the present worth of the operation and maintenance costs to interest rates of 5 percent, 10 percent, 12 percent, and 15 percent were conducted and is also summarized in Table 6.9-1. As shown, the present worth of each alternative increases as the interest rate decreases since the higher the interest rate, the less money is needed initially to finance the annual operation and maintenance costs over the 30 years. The use of lower interest rates may also be interpreted as an inclusion of inflation rates. For example, a 5 percent interest rate may be interpreted as a 10 percent time value of money with a 5 percent inflation rate. The present worth of remedial alternatives with high annual operation and maintenance costs compared to capital cost are more sensitive to interest rates than those with low operation and maintenance costs relative to capital costs. This fact indicates that if inflation is considered significant, alternatives with high operation and maintenance costs become less attractive economically.

6.2 ALTERNATIVE 1 EVALUATION

The No-Action Alternative would apply no remediation to the site. It consists of monitoring groundwater, air, and surface water to observe the migration of site contaminants.

6.2.1 Effectiveness

Endangerment Assessment

Results of analysis for the No-Action Alternative indicate that inhalation and ingestion of lead under the high dose cases are unacceptably high. Such high doses result from calculations based on the lead oxide--almost pure lead--in the site's waste piles.

Risks based on hazard indices for ingestion under high dose cases for both the onsite worker and onsite residential scenarios are unacceptably high because of the high contaminant values used in the calculations. For the onsite worker scenario, risks for both inhalation and base case ingestion are far below the AIC. By contrast, the highest risks (young children) and adult risks under the onsite and offsite residential scenarios all exceed the AIC, with a maximum AIC of 11.2 for inhalation and 34.6 for ingestion. The various scenarios of the No-Action Alternative indicate that this alternative is unacceptable as a remedial option.

Dilution calculations were performed to estimate the distance downstream of the East Doane Lake outfall to the Willamette at which the concentration of lead in the discharge plume would exceed 0.05 mg/l, which is the Oregon Water Quality Standard. Using the maximum observed dissolved lead concentration of 0.28 mg/l in East Doane Lake, that distance is 40 feet for a discharge of 0.05 cfs and 160 feet for a discharge of 0.5 cfs. In the former case, the maximum plume width would be 5 feet; in the latter case, 10 feet. Of primary economic and recreation concern are potential effects on anadromous (migratory) salmonids. Both juveniles and adults in the Willamette migrate past the site on their way to and from upstream spawning areas. Because of the shallowness of the beach adjacent to the discharges, adults would not be expected to move through concentrated areas of the plume and should suffer little impact from their limited exposures. Juvenile salmon migrate downstream along shallow beaches or used them as refuges from predators. While a significant percentage of outmigrating juvenile salmonids will pass through the plume, short exposures are expected to result in perhaps very minor stress to respiration and metabolism but not kill significant numbers of fish.

Reliability

This alternative, by definition, is not a reliable method of remediating the site problems. The methods proposed for monitoring are, however, very reliable. The reliability factor for this alternative, if acceptable, would be high.

Conformance to ARAR's

Because the No-Action Alternative would apply no remediation to the site, it would not meet the ARAR for lead in surface water, since the lead concentration of East Doane Lake is, on average, slightly higher than the MCL or the Oregon Water Quality Standard of 0.05 mg/l. The National Ambient Air Quality Standard (NAAQS) for lead of 1.5 ug/m3 for a calendar quarter would not be exceeded during periods of no or low site activity. The MCL for lead would be exceeded in some of the monitoring wells, at least at the outset. As pH values in the shallow aquifer system continue to rise, the lead content of the aquifer water will likely continue to decline. At present, there is no consumptive use of the aquifer, and publicity combined with institutional controls may continue to prevent consumptive use.

The No-Action Alternative would probably not always meet the Oregon Water Quality Standard for discharges to the Willamette River, since the average lead content of East Doane Lake water is 0.09 mg/l.

Finally, the No-Action Alternative does not address materials on site that are primary or secondary sources of lead, i.e. battery casings, matte, surface soils, subsurface soils and sediments. Each of those materials, in varying quantities and concentrations, fails the standard of EP Toxicity for lead. The ability of the No-Action Alternative to meet ARARs is judged to be low.

Reduction in Toxicity, Mobility, or Volume

This alternative does not reduce toxicity, mobility, or volume of contaminants on-site. The factor for reduction in toxicity, mobility, or volume is low.

6.2.2 Implementability

Constructability

The construction work in this alternative involves the installation of air monitors and signs. These will be done by standard and proven methods. The constructability factor for this alternative is, therefore, considered high.

Performance

Since there is no remedial action performed on site, the performance factor is considered low.

Safety

Safety during installation of monitoring equipment would not be an issue. The safety factor is considered high.

Time Required

The time required to perform installation is outlined in the following sequential activities:

°	Specification and procurement	3 months
°	Installations	<u>1 month</u>
	Total time	4 month

Permitting

The No-Action Alternative includes installation of four additional high volume air monitors (HIVOL). These require an electrical 110 volt power source. Depending on the power source location, the electrical termination, and disposition of the connecting cable, a construction permit may be required. No other permit requirements are foreseen.

Community Concerns

Very little community concern has been expressed about the Gould site. Some community opposition to the disposal of battery casings in St. John's Landfill has been expressed. This alternative would avoid that disposal method. No other community concerns, expressed or assumed, would be addressed by the No-Action Alternative. Its ability to satisfy community concerns is rated low.

Institutional Requirements

In order to allow the No-Action Alternative to be implemented, a number of institutional requirements would have to be waived and institutional controls would have to be implemented. Foremost is the fact that ARARs for the Gould site would not be met, and none of the six waivers under SARA could be used to justify the shortcoming.

The range of institutional controls available to be applied to the Gould site has been addressed in Section 4 of this report. They include water permit restrictions, zoning restrictions, land use restrictions, deed restrictions, and sale restrictions. For the No-Action Alternative, water permit restrictions by themselves would not be particularly useful because of the lack of a mechanism for controlling well drilling in the shallow aquifer. Zoning restrictions currently restrict any use other than heavy industrial in the study area. The land use restriction mechanism of the Oregon Notice of Environmental Hazards Act could be used to restrict future site development. Finally, as the property owner, Gould Inc. has the right to place notices on the deed or other instrument restricting use or covenanting not to sell the property. However, the effectiveness of institutional controls in allowing the No-Action Alternative to meet remedial objectives is judged to be low, as is the performance rating from an institutional requirement stance.

6.2.3 Cost Analysis

The costs associated with this alternative are divided into two categories. The first is capital cost which includes the purchase and installation of warning signs and HIVOL airborne monitors. The second is the operating costs for sampling and samples analysis for a 30-year period. Operating costs are discounted to present worth values for comparison purposes. Detailed cost breakdown information is provided in Appendix C.

	<u>Capital Costs</u>	<u>O&M @ 12% Present Worth</u>	<u>Total Cost</u>
Alternative #1	\$34,692	\$156,962	\$191,654

Assumptions include:

- ° Sampling duration - 30 years
- ° Semi-annual reporting
- ° Present Worth Costing - 30 years @ 12 percent

6.3 ALTERNATIVE 2A EVALUATION

Alternative 2A comprises removal and off-site disposal of the surface piles of battery casing fragments, surface treatment with lime, and a long-term monitoring program.

6.3.1 Effectiveness

Endangerment Assessment

Alternative 2A achieves 95.1 percent of the overall reduction in lead exposure achieved by the most protective alternative, Alternative 10.

Short-term risks for workers onsite would be negligible because workers onsite would follow health and safety procedures and use personal protective equipment where warranted. In addition, fencing and other controls would be used to prevent members of the public from entering the site. The hazard index for inhalation of lead by offsite workers at the fenceline is well below the acceptable chronic intake.

Reliability

The removal and disposal of the surface piles of battery casing fragments is considered a reliable means of reducing air pollution from the site. Lime treatment, however, will require frequent testing to

ascertain that soil pH is within the required range, and will demand regular repetition to replace lime lost in runoff. Site monitoring equipment will require continued maintenance, as well. The reliability of this alternative is judged to be moderate.

Conformance with ARARs

Alternative 2A consists of removal of surface piles of battery casings, treatment of the surface with lime, and monitoring. The application of lime to the surface would raise the pH of site runoff into East Doane Lake, and of the lake itself. The raised pH of the lake would reduce the dissolved component of lead in the lake. This reduction may be adequate to allow East Doane Lake to achieve the ARAR for lead of 0.05 mg/l.

A raised lake pH would likely not be adequate to allow the lake always to meet the Oregon Water Quality Standard for the Willamette River, since the average East Doane Lake lead concentration is 0.09 mg/l. However, a reduction in dissolved lead would result from a raised pH, and any Doane Lake discharge would likely meet the standard within a small mixing zone.

Since the National Ambient Air Quality Standard (NAAQS) for lead of 1.5 ug/m3 for a calendar quarter would not be exceeded for the No-Action Alternative during periods of no or low site activity, it would not be exceeded for Alternative 2A either. Total suspended particulates would probably rise because of the availability of lime dust to become wind-borne. But the percentage of lead in airborne particulates would be reduced over the No-Action Alternative.

The MCL for lead would continue to be exceeded in some of the monitoring wells, at least at the outset. The action of the lime would serve to gradually and continuously immobilize the lead in soils, however, which would produce over time the effect of lowering the dissolved lead component of ground-water contamination. At present, there is no consumptive use of the aquifer, and publicity combined with institutional controls may continue to prevent consumptive use.

Finally, except for the immobilizing effect of the lime, Alternative 2A does not address materials on site that are primary or secondary sources of lead, i.e. battery casings, matte, surface soils, subsurface soils and sediments. Each of those materials, in varying quantities and concentrations, fails the standard of EP Toxicity for lead. For Alternative 2A, achievement of ARARs is judged to be low to moderate.

Reduction in Toxicity, Mobility, or Volume

Alternative 2A does not significantly reduce the volume or toxicity of the site contaminants. Contaminant mobility is reduced by decreasing the availability of site contaminants for dissolution in surface water. This alternative is rated low for reducing contaminant toxicity, mobility or volume.

6.3.2 Implementability

Constructability

Alternative 2A would be accomplished using conventional machinery and techniques. It is therefore rated high for constructability.

Performance

The intent of this alternative is to mitigate health and environmental effects of site contaminants due to airborne pollution or exposure to contaminated surface water; and to reduce the off-site migration of contaminants in the air and in surface water. Removal of the surface piles is expected to substantially reduce the entrainment of dust from the site by wind. Re-application of lime every two years will likely be required to maintain the long-term reduction of contaminant migration in surface water. When combined with appropriate institutional controls, the performance of this alternative is judged to be moderate.

Safety

Under this alternative, it will be necessary to transport contaminated material on the public highways to a RCRA-approved disposal site. Applicable DOT and EPA regulations for the transport of hazardous materials will be followed. During remediation, worker safety issues similar to those for minor earthmoving projects will arise. Hazards associated with site contaminants will be controlled by appropriate respiratory protection, proper safety attire and the application of dust suppression techniques.

The monitoring program for Alternative 2A will be similar to that discussed under the No-Action Alternative in Section 5.2.1. The monitoring program will use monitoring wells to look for changes in the groundwater contaminant plume. Implementation of the monitoring program will not raise any serious safety issues. Overall, however, this alternative is rated moderate for safety.

Time Required

Alternative 2A could be executed in one year, including planning, review, contracting and completion. There are no site conditions or known zoning requirements which might delay execution. Beneficial effects of the removal of the surface piles will be immediate. Beneficial effects of treating the site surface with lime will accrue gradually, as lime leaches into the East Doane Lake remnant. Implementation of this alternative is dependent on the availability of an off-site disposal location. However, it is expected that a suitable disposal location can be found for the small volume of material in the surface piles.

Permitting Requirements

This alternative involves the off-site handling or disposal of battery casings, probably in a regulated landfill, because of the relatively small amount which must be done in accordance with applicable regulations pertaining to transportation and disposal of designated hazardous waste under RCRA (40 CFR 263) and the EPA Off-Site Policy. In construction, site drainage systems are emplaced. Additionally, three (HIVOL) air monitors have to be relocated and one new one installed. Construction permits will be required for these activities. No other permit requirements are foreseen.

Community Concerns

Alternative 2A would address only the community concern regarding disposal of battery casings in St. John's Landfill. To some extent, community concern over airborne lead from the site would be alleviated by this alternative. Effectiveness in satisfying community concerns is judged to be low to moderate.

Institutional Controls

For Alternative 2A, water permit restrictions by themselves would not be particularly useful because of the lack of a mechanism for controlling well drilling in the shallow aquifer. Zoning restrictions currently restrict any use other than heavy industrial in the study area. The land use restriction mechanism of the Oregon Notice of Environmental Hazards Act could be used to restrict future site development.

As the property owner, Gould Inc. has the right to place notices on the deed or other instrument restricting use or covenanting not to sell

the property. This control would be absolutely effective in preventing contact with contaminated groundwater, since the plume of dissolved lead in excess of 0.05 mg/l does not extend off the property. Such a control would be equivalent to meeting the ARAR of the MCL for lead. The effectiveness rating for institutional controls is judged to be low to moderate.

Availability

The equipment and materials needed to implement Alternative 2A are readily available. The availability of Alternative 2A is judged to be high.

6.3.3 Cost Analysis

The costs associated with this alternative are divided into two categories. The first is capital cost which includes site grading, lakeshore erosion control, parking lot drainage modification, original soil treatment, water truck rental, and installation of airborne monitors. The second is the operating cost which includes off-site disposal of battery casings on the surface, follow-up soil treatment after five years, and site monitoring. Operating costs are discounted to present worth for comparison purposes. Detailed cost breakdown information is provided in Appendix C.

	<u>Capital Costs</u>	<u>O&M @ 12% Present Worth</u>	<u>Total Cost</u>
Alternative #2A	\$683,611	\$382,092	\$1,065,703

Assumptions include:

- ° Site grading - 8 acres
- ° Battery casings on surface - 1042 tons
- ° Lime treatment - 29,040 sq. yd.
- ° Costing Interest Rate - 12 percent

6.4 ALTERNATIVE 2B EVALUATION

Alternative 2B comprises removal and off-site disposal of the surface piles of battery casing fragments, site regrading and blocking of the overflow from the East Doane Lake remnant, surface capping, and a long-term monitoring program.

6.4.1 Effectiveness

Endangerment Assessment

Alternative 2B achieves 98.6 percent and 97.9 percent of the overall lead exposure reduction achievable by Alternative 10 for the base case and high dose case, respectively. The only exposure scenario that results in excessive exposure is the onsite residential exposure scenario, which is precluded under this alternative by institutional controls.

Short-term risks for workers onsite would be negligible because workers onsite would follow health and safety procedures and use personal protective equipment where warranted. In addition, fencing and other controls would be used to prevent members of the public from entering the site. The hazard index for inhalation of lead by offsite workers at the fenceline is well within the acceptable chronic intake.

Reliability

The removal and disposal of the surface piles of battery casing fragments is considered a reliable means of reducing air pollution from the site. Surface capping is a proven technology, and is considered adequately reliable. Occasional inspection of the cap will be required to ascertain that the cap does not dry and crack. Site monitoring equipment will require occasional maintenance, as well. The reliability of this alternative is judged to be moderate to high.

Conformance with ARARs

Alternative 2B consists of removal of surface piles of battery casings, regrading the site to drain away from East Doane Lake, capping contaminated surface soils with soil/bentonite, blocking the East Doane Lake outlet to the Willamette, and monitoring. Through time, the pH of East Doane Lake can be expected to rise, as the sulfate plume on the site is further diluted. A gradual rise in lake pH will gradually reduce the dissolved component of lead in the lake. This reduction, along with continued settling of the lake, may be adequate to allow East Doane Lake to achieve the ARAR for lead of 0.05 mg/l. With the outlet to the Willamette closed, the Willamette will be protected from any contaminant plume from East Doane Lake discharge.

Since the National Ambient Air Quality Standard (NAAQS) for lead of 1.5 ug/m3 for a calendar quarter would not be exceeded for the No-Action

Alternative during periods of no or low site activity, it would not be exceeded for Alternative 2B either. During actual site remediation, total suspended particulates would probably rise, as would the concentration of airborne lead. The percentage of lead in airborne particulates would be significantly reduced over the long-term.

The MCL for lead would continue to be exceeded in some of the monitoring wells, at least at the outset. Through time, the ground-water pH of all on-site wells can be expected to rise as the sulfate plume on the site is further diluted. A gradual rise in ground-water pH will gradually reduce the dissolved component of lead in the shallow aquifer system. Over time, this reduction is expected to allow ground water in on-site wells to achieve the ARAR for lead of 0.05 mg/l. At present, there is no consumptive use of the aquifer, and publicity combined with institutional controls will continue to prevent onsite consumptive use.

Alternative 2B does not directly treat materials on site that are primary or secondary sources of lead, i.e. battery casings, matte, surface soils, subsurface soils and sediments. Each of those materials, in varying quantities and concentrations, fails the standard of EP Toxicity for lead.

Under SARA, EPA is authorized to permit remedial action that does not meet all ARARs by invoking any of six waivers. One of the waivers is that the proposed remedial action must be as protective of human health and the environment as meeting the ARAR would be. With the institutional controls proposed by Gould Inc., the ability of this alternative to meet the conditions for invocation of the waiver is adequate. Therefore, the performance rating of this alternative to meet ARARs, while only moderate without institutional controls, is high when the controls are considered.

Reduction in Toxicity, Mobility, or Volume

Alternative 2B moderately reduces the volume and the toxicity of the site contaminants. Contaminant mobility is reduced by decreasing the availability of site contaminants for wind entrainment, dissolution in surface water, or migration into ground water. Contaminant toxicity is indirectly reduced by making the contaminants less available for contact with biological organisms. This alternative is rated moderate to high for reducing contaminant toxicity, mobility or volume.

6.4.2 Implementability

Constructability

Alternative 2B would be accomplished using conventional machinery and techniques. It is therefore rated high for constructability.

Performance

The intent of this alternative is to mitigate health and environmental effects of site contaminants due to airborne pollution, exposure to contaminated surface water, or exposure to primary source material at the surface and secondary source materials (surface soils); and to reduce the off-site migration of contaminants in the air, in surface water, and in ground water. Removal of the surface piles is expected to substantially reduce the entrainment of dust from the site by wind. Site regrading and blocking of the overflow from the East Doane Lake remnant will prevent the accumulation of runoff in the lake remnant, and halt the transport of contaminated surface water off site. Site capping will place a barrier between the remaining contaminants and the environment, thereby reducing their availability for off-site transport by surface water and ground water, as well as reducing the chance of direct contaminant ingestion in soils. When combined with appropriate institutional controls, the performance of this alternative is judged to be high.

Safety

Under this alternative, it will be necessary to transport contaminated material on the public highways to a RCRA-approved disposal site. Applicable DOT and EPA regulations for the transport of hazardous materials will be followed. During remediation, worker safety issues similar to those for minor earthmoving projects will arise. Hazards associated with site contaminants will be controlled by appropriate respiratory protection, proper safety attire and the use of dust suppression techniques.

The monitoring program for Alternative 2B will be similar to that discussed under the No-Action Alternative in Section 5.2.1. The monitoring program will use monitoring wells to look for changes in the groundwater contaminant plume. Implementation of the monitoring program will not raise any serious safety issues. Overall, this alternative is rated moderate to high for safety.

Time Required

Alternative 2B could be executed in one year, including planning, review, contracting and completion. There are no site conditions or known zoning requirements which might delay execution. Beneficial effects of remediation under this alternative will be immediate. Implementation is dependent on the availability of an off-site disposal location. However, it is expected that a suitable disposal location can be found for the relatively small volume of material in the surface piles.

Permitting Requirements

This alternative involves the off-site disposal of battery casings in a regulated landfill, which must be done in accordance with applicable regulations pertaining to transportation and disposal of designated hazardous waste under RCRA (40 CFR 263) and the EPA Off-Site Policy. In construction, site drainage systems are emplaced and air monitors have to be relocated and installed. Construction permits may be required for these activities. No other permit requirements are foreseen.

Community Concerns

Alternative 2B would address the community concern about high levels of airborne lead as well as the effects of airborne lead on workers' health. This alternative would not restrict any land use outside of the Gould property, thus alleviating concern about future development of the Doane Lake area because of remaining site contaminants. Performance considering satisfaction of community concerns is judged to be high.

Institutional Controls

In order to allow implementation of Alternative 2B, EPA would have to grant a waiver from the SARA requirement that ARARs be met on site. However, the basis for granting that waiver is sound; because of institutional controls, the alternative is as protective of human health and the environment as is meeting all ARARs for the site.

For Alternative 2B, water permit restrictions by themselves would not be particularly useful because of the lack of a mechanism for controlling well drilling in the shallow aquifer. Zoning restrictions currently restrict any use other than heavy industrial in the study area. The land use restriction mechanism of the Oregon Notice of

Environmental Hazards Act could be used to restrict future site development.

As the property owner, Gould Inc. has the right to place notices on the deed or other instrument restricting use or covenanting not to sell the property. This control would be absolutely effective in preventing contact with contaminated ground water, since the plume of dissolved lead in excess of 0.05 mg/l does not extend off the property. Such a control would be equivalent to meeting the ARAR of the MCL for lead. The control would also be highly effective in preventing contact with contaminated soils; all soils that present an unacceptable health risk will be buried under two feet of soil/bentonite. As part of Alternative 2B, Gould Inc. will make use of institutional controls regarding future land ownership and use. Gould will covenant to maintain ownership and exercise limited use of the property in perpetuity, through the execution of an instrument, legally binding on Gould Inc., as well as on its heirs and successors. Gould Inc. will include a provision in the instrument regarding the possible future sale of the property. At such future time that Gould may, for circumstances unforeseen, be in a position that favors or requires the sale of the property, Gould or its heirs or successors will then re-evaluate the need for additional site remediation to protect human health and the environment. From an institutional control viewpoint, Alternative 2B is judged to have a high rating.

Availability

The equipment and materials needed to implement Alternative 2B are readily available. The availability of Alternative 2B is judged to be high.

6.4.3 Cost Analysis

The costs associated with this alternative are divided into two categories. The first is capital cost which includes site grading, parking lot drainage modification, installation of airborne monitors, surface capping and revegetation. The second is the operating cost which includes off-site disposal of surface battery casings, water truck rental, and site monitoring. Operating costs are discounted to present worth for comparison purposes. Detailed cost breakdown information is provided in Appendix C.

	<u>Capital Costs</u>	<u>O&M @ 12% Present Worth</u>	<u>Total Cost</u>
Alternative #2B	\$1,239,065	\$138,952	\$1,378,017

Assumptions include:

- Site grading - 8 acres
- Surface capping - 7.5 acres
- Revegetation - 10 acres
- Battery casings on surface - 1042 tons
- Costing interest rate - 12 percent

6.5 ALTERNATIVE 8 EVALUATION

Alternative 8 comprises removal and off-site disposal of the surface piles of battery casing fragments and East Doane Lake sediments, site regrading and blocking of the overflow from the East Doane Lake remnant, surface capping, and a long-term monitoring program.

6.5.1 Effectiveness

Endangerment Assessment

Alternative 8 achieves 98.6 percent and 97.9 percent of the overall reduction to lead exposure achievable by Alternative 10 for the base case and high dose case, respectively.

Short-term risks for workers onsite would be negligible because workers onsite would follow health and safety procedures and use personal protective equipment where warranted. In addition, fencing and other controls would be used to prevent members of the public from entering the site. The hazard index for inhalation of lead by offsite workers at the fenceline is well within the acceptable chronic intake.

Reliability

The removal and disposal of the surface piles of battery casing fragments is considered a reliable means of reducing air pollution from the site. The removal and disposal of the East Doane Lake sediments is considered a reliable means of reducing pollution of site surface water. Surface capping is a proven technology, and is considered moderately reliable. Frequent inspection of the cap will be required to ascertain that the cap does not dry and crack. Site monitoring equipment will require continued maintenance, as well. The reliability of this alternative is judged to be moderate to high.

Conformance with ARARs

Alternative 8 consists of removal of surface piles of battery casings, regrading the site to drain away from East Doane Lake, capping contaminated surface soils with soil/bentonite, blocking the East Doane Lake outlet to the Willamette, removal of contaminated sediments, filtration of East Doane Lake, and monitoring. The main difference between the ability of this alternative to meet ARARs and the ability of Alternative 2B to meet ARARs is in the time required to reduce the lead content of East Doane Lake to 0.05 mg/l. Removal of contaminated sediments containing leachable lead, combined with filtration of the lake, will reduce the amount of time necessary to reduce the lead content of the lake water. Through time, the pH of East Doane Lake can be expected to rise, as the sulfate plume on the site is further diluted. A gradual rise in lake pH will gradually reduce the dissolved component of lead in the lake. Filtration of the lake will more quickly reduce the non-dissolved portion of lake lead than continued settling. Reduction of both dissolved and non-dissolved lake lead will, in all likelihood, be adequate to allow East Doane Lake to achieve the ARAR for lead of 0.05 mg/l. With the outlet to the Willamette closed, the Willamette will be protected from any contaminant plume from East Doane Lake discharge.

Since the National Ambient Air Quality Standard (NAAQS) for lead of 1.5 ug/m³ for a calendar quarter would not be exceeded for the No-Action Alternative during periods of no or low site activity, it would not be exceeded for Alternative 8 either. During actual site remediation, total suspended particulates would probably rise, as would the concentration of airborne lead. The percentage of lead in airborne particulates would be significantly reduced over the long-term.

The MCL for lead would continue to be exceeded in some of the monitoring wells, at least at the outset. Through time, the ground-water pH of all on-site wells can be expected to rise as the sulfate plume on the site is further diluted. A gradual rise in ground-water pH will gradually reduce the dissolved component of lead in the shallow aquifer system. Over time, this reduction may be adequate to allow groundwater in on-site wells to achieve the ARAR for lead of 0.05 mg/l. At present, there is no consumptive use of the aquifer, and publicity combined with institutional controls will continue to prevent onsite consumptive use.

Alternative 8 does not directly treat most of the materials on site that are primary or secondary sources of lead, i.e. battery casings, matte, surface soils, and subsurface soils. The alternative does address contaminated sediments. Each of the remaining materials, in

varying quantities and concentrations, fails the standard of EP Toxicity for lead.

Under SARA, EPA is authorized to permit remedial action that does not meet all ARARs by invoking any of six waivers. One of the waivers is that the proposed remedial action must be as protective of human health and the environment as meeting the ARAR would be. With the institutional controls proposed by Gould Inc., the ability of this alternative to meet the conditions for invocation of the waiver is adequate. Therefore, the performance rating of this alternative to meet ARARs, while only moderate without institutional controls, is high when the controls are considered.

Reduction in Toxicity, Mobility, or Volume

Alternative 8 does not significantly reduce the volume nor directly reduce the toxicity of the site contaminants. Contaminant mobility is reduced by decreasing the availability of site contaminants for wind entrainment, dissolution in surface water, or migration into ground water. Contaminant toxicity is indirectly reduced by making the contaminants less available for contact with biological organisms. This alternative is rated moderate to high for reducing contaminant toxicity, mobility or volume.

6.5.2 Implementability

Constructability

Alternative 8 would be accomplished using conventional machinery and techniques. It is therefore rated high for constructability.

Performance

The intent of this alternative is to mitigate health and environmental effects of site contaminants due to airborne pollution, exposure to contaminated surface water, or exposure to primary source material in soils; and to reduce the off-site migration of contaminants in the air or in surface water. Removal of the surface piles is expected to substantially reduce the entrainment of dust from the site by wind. Site regrading and blocking of the overflow from the East Doane Lake remnant will prevent the accumulation of runoff in the lake remnant, and halt the transport of contaminated surface water off site. Site capping will place a barrier between the remaining contaminants and the environment, thereby reducing their availability for off-site transport by sur-

face water and direct contaminant ingestion with soils. When combined with appropriate institutional controls, the performance of this alternative is judged to be high.

Safety

Under this alternative, it will be necessary to transport contaminated material on the public highways to a RCRA-approved disposal site. Applicable DOT and EPA regulations for the transport of hazardous materials will be followed. During remediation, worker safety issues similar to those for minor earthmoving projects will exist. Hazards associated with site contaminants will be reduced by appropriate respiratory protection, proper safety attire and the application of dust suppression techniques.

The monitoring program for Alternative 8 will be similar to that discussed under the No-Action Alternative in Section 5.2.1. The monitoring program will use monitoring wells to look for changes in the groundwater contaminant plume. Implementation of the monitoring program will not raise any serious safety issues. The additional equipment to be used in this alternative suggests a moderate safety rating.

Time Required

Alternative 8 could be executed in one year, including planning, review, contracting and completion. There are no site conditions or known zoning requirements which might delay execution. Beneficial effects of remediation under this alternative will be immediate. Implementation is dependent on the availability of an off-site disposal location. However, it is expected that a suitable disposal location can be found for the small volume of material in the surface piles and the sediments.

Permitting Requirements

This alternative involves the off-site disposal of battery casings and sediments in a regulated landfill, which must be done in accordance with applicable regulations pertaining to transportation and disposal of designated hazardous waste under RCRA (40 CFR 263). In construction, site drainage systems are emplaced. Additionally, three (HIVOL) air monitors have to be relocated and one new one installed. Construction and dredging permits may be required for these activities. No other permit requirements are foreseen.

Community Concerns

Alternative 8 would address the community concern about high levels of airborne lead as well as the effects of airborne lead on workers' health. This alternative would not restrict any land use outside of the Gould property, thus alleviating concern about future development of the Doane Lake area because of remaining site contaminants. The alternative is rated high for performance in satisfying community concerns about the site.

Institutional Controls

In order to allow implementation of Alternative 8, EPA would have to grant a waiver from the SARA requirement that ARARs be met on site. However, the basis for granting that waiver is sound; because of institutional controls, the alternative is as protective of human health and the environment as is meeting all ARARs for the site.

For Alternative 8, water permit restrictions by themselves would not be particularly useful because of the lack of a mechanism for controlling well drilling in the shallow aquifer. Zoning restrictions currently restrict any use other than heavy industrial in the study area. The land use restriction mechanism of the Oregon Notice of Environmental Hazards Act could be used to restrict future site development.

As the property owner, Gould Inc. has the right to place notices on the deed or other instrument restricting use or covenanting not to sell the property. This control would be absolutely effective in preventing contact with contaminated ground water, since the plume of dissolved lead in excess of 0.05 mg/l does not extend off the property. Such a control would be equivalent to meeting the ARAR of the MCL for lead. The control would also be highly effective in preventing contact with contaminated soils; all soils that present an unacceptable health risk will be buried under two feet of soil/bentonite. As part of Alternative 8, Gould Inc. will make use of institutional controls regarding future land ownership and use. Gould will covenant to maintain ownership and exercise limited use of the property in perpetuity, through the execution of an instrument, legally binding on Gould Inc., as well as on its heirs and successors. Gould Inc. will include a provision in the instrument regarding the possible future sale of the property. At such future time that Gould may, for circumstances unforeseen, be in a position that favors or requires the sale of the property, Gould or its heirs or successors will then re-evaluate the need for additional site

remediation to protect human health and the environment. From an institutional control viewpoint, Alternative 8 is judged to have a high rating.

Availability

The equipment and materials needed to implement Alternative 8 are readily available. The availability of Alternative 8 is judged to be high.

6.5.3 Cost Analysis

The costs associated with this alternative are divided into two categories. The first is capital cost which includes site grading, parking lot restructuring, lakeshore erosion control, installation of airborne monitors, pumping and filtering of East Doane Lake, surface capping, and revegetation. The second is the operating cost which includes the off-site disposal of surface battery casings and lake sediments, water truck rental, and site monitoring. Operating costs are discounted to present worth for comparison purposes. Detailed cost breakdown information is provided in Appendix C.

	<u>Capital Costs</u>	<u>O&M @ 12% Present Worth</u>	<u>Total Cost</u>
Alternative #8	\$2,942,908	\$ 181,793	\$3,124,701

Assumptions include:

- ° Site grading - 2.3 acres
- ° Surface capping - 7.5 acres
- ° Revegetation - 10 acres
- ° Pumping Time - 550 hours
- ° Battery Casings on surface - 1042 tons
- ° Lake sediments - 5560 tons
- ° Costing Interest Rate - 12 percent

6.6 ALTERNATIVE 10 EVALUATION

Alternative 10 consists of excavation of battery casings and matte, separation and recycle of battery casings, regrading the site to drain away from East Doane Lake, stabilization of contaminated surface soils, subsurface soils, sediments, and matte, blocking the East Doane Lake outlet to the Willamette, filtration of East Doane Lake, and monitoring.

6.6.1 Effectiveness

Endangerment Assessment

Exposure under Alternative 10 are all acceptable, and are marginally lower than for any other alternative.

Short-term risks for workers onsite would be negligible because workers onsite would follow health and safety procedures and use personal protective equipment where warranted. In addition, fencing and other controls would be used to prevent members of the public from entering the site. The hazard index for inhalation of lead by offsite workers at the fenceline is well below the acceptable chronic intake.

Reliability

The removal of and treatment of contaminated material in the methods prescribed by this alternative will remove recharge contaminant sources for ground water and prevent airborne migration of contaminants. The separation of battery casing materials for off-site recycle would require a high degree of O&M to ensure proper performance. Fixation of heavy metals in soil has been performed at other sites with a certain degree of reliability. The agent binds the heavy metals in a matrix with soil making them nonmobile. Future mobility could only be induced by a chemical or physical means such as oxidation with an acid or mechanical disturbance. The placement of a soil and vegetative cover over the backfill will further prevent oxidation by weathering. To ensure reliability, the fixation agent will be selected from bench scale and pilot test data. These tests will determine the agent most suitable and dosing requirement to meet leachability testing. The reliability of this alternative is considered low, because of the many technical elements involved and because of the O&M requirements.

Conformance with ARARs

Removal of contaminated sediments containing leachable lead, combined with filtration of the lake, will reduce the amount of time necessary to reduce the lead content of the lake water. Through time, the pH of East Doane Lake can be expected to rise, as the sulfate plume on the site is further diluted. A gradual rise in lake pH will gradually reduce the dissolved component of lead in the lake. Filtration of the lake will more quickly reduce the non-dissolved portion of lake lead than continued settling. Reduction of both dissolved and non-dissolved lake lead will, in all likelihood, be adequate to allow East

Doane Lake to achieve the ARAR for lead of 0.05 mg/l. With the outlet to the Willamette closed, the Willamette will be protected from any contaminant plume from East Doane Lake discharge.

Since the National Ambient Air Quality Standard (NAAQS) for lead of 1.5 ug/m3 for a calendar quarter would not be exceeded for the No-Action Alternative during periods of no or low site activity, it would not be exceeded long-term for Alternative 10 either. During the years of actual site remediation for Alternative 10, total suspended particulates would show a significant rise, as would the concentration of airborne lead. The percentage of lead in airborne particulates would be significantly reduced over the long-term.

The MCL for lead would continue to be exceeded in some of the monitoring wells, at least at the outset. Through time, the ground-water pH of all on-site wells can be expected to rise as the sulfate plume on the site is further diluted. A gradual rise in ground-water pH will gradually reduce the dissolved component of lead in the shallow aquifer system. Over time, this reduction couple with removal of all primary source materials and stabilization of all secondary source materials should be adequate to allow groundwater in on-site wells to achieve the ARAR for lead of 0.05 mg/l. Actual time required to achieve the ARAR will depend on the amount of precipitation received, since runoff will be diverted away from the site and made unavailable as a source of recharge. At present, there is no consumptive use of the aquifer, and publicity combined with institutional controls may continue to prevent consumptive use until the aquifer achieves the ARAR.

Alternative 10 directly treats the materials on site that are primary or secondary sources of lead, i.e. battery casings, matte, surface soils, subsurface soils, and sediments. No materials that fail the standard of EP Toxicity for lead will remain uncontrolled at the end of remediation under Alternative 10. The performance of Alternative 10 in meeting ARARs for the Gould site is judged to be high.

Reduction in Toxicity, Mobility, or Volume

Although this alternative would greatly reduce the volume and toxicity of hazardous materials on the Gould site, the volume of the treated soil material will actually increase about 0.5 percent due to the additive and 5 percent because compaction by normal methods will achieve 95 percent of the density of the in-situ conditions. Engineering studies performed to date show that the toxicity of the separated plastic and ebonite, expressed in terms of TCLP concentration, is not reduced to 5

mg/l. For plastic, the TCLP following separation is probably within a acceptable range for two reasons: (1) recycle will reduce the leachability of lead in the plastic; and (2) RCRA regulations allow recycle even if TCLP (or EP Toxicity) for lead is exceeded (see Alternative 10 discussion under Availability). For ebonite, however, the TCLP results received in engineering study analyses are intolerably high from the point of view of NL Industries and Gould. Total lead results as high as 40,000 mg/kg were obtained in Poly-Cycle samples of separated ebonite; TCLP results as high as 250 mg/l and 200 mg/l were obtained from Ace Battery tests and Poly-Cycle tests, respectively. Further, the 250 mg/l TCLP result from the Ace Battery test was obtained on an ebonite sample that had been acid-washed and rinsed with deionized water.

Even if these materials are recyclable under RCRA, NL Industries and Gould are quite unwilling to accept the liability that attends recycle of materials with such high total lead results. Simply put, from a corporate point of view, use of the ebonite in drilling muds, while allowable under RCRA today, could certainly prove to be folly under CERCLA tomorrow. Alternative 10 is judged to be high in reduction of toxicity, mobility, or volume of site contaminants, but low in terms of its ability to reduce toxicity of materials to be recycled.

6.6.2 Implementability

Constructability

The site work and construction of facilities in this alternative will be performed using standard methods and equipment. However, a significant amount of equipment needs to be brought on site. The site is in an industrial area with good utility access; however, disruption of local services or utilities is foreseen during the construction period. For Alternative 10, which involves excavation at the site, the location of power lines along the northwest edge of the Gould property must also be considered. The Bonneville Power Administration (BPA) maintains a 115-kV transmission line on the Rhone-Poulenc and ESCO properties that feeds one of the BPA's Direct Service Industries. The BPA indicates that this line serves a heavy user of power that typically shuts down for only a few days each year for maintenance. Thus, removal or relocation of the transmission line may entail a loss of revenue for the power user, as well as additional costs associated with on-site work and new construction. On the other hand, the operation of heavy equipment near an energized transmission line may constitute a significant safety hazard. In addition, Portland Power and Light maintains a power line alongside the transmission line, at roughly half the elevation of

the BPA line. The constructability factor of this alternative is considered moderate.

Performance

The treatment plants, once set-up, would be manned by locally trained operators with supervision by a small technical staff. Process performance would be controlled according to strict procedures and a quality control program. Backfilling of the treated soils will be done according to standard construction procedures. Therefore, no specialist requirements are foreseen to achieve performance goals. The soil, when fixed and the soil-vegetative protective cover is in place, should remain that way indefinitely. The battery casings, when separated and removed off site, will present no further problem for this site. Performance factor for this alternative is considered high.

Safety

The processes for battery casings and soils use no chemicals that are harmful by normal contact to the operators. The battery casing and soils materials could be harmful if inhaled or ingested. Personnel in these areas will wear protective clothing and gloves. In the dry handling areas the operators will be required to wear safety masks. On-site contractors handling waste materials will be required to have personnel who are health and safety trained. Technical staff will implement safety programs in the process plant. In the training program for local operators, a segment will be devoted to health and safety. The safety for this alternative is considered to be moderate.

Time Required

The time required to perform this alternative is outlined in the following sequential activities.

Remedial design, specification, procurement, contracting, and permitting	12 months
Facility construction	6 months
Excavating and processing battery casings and soils materials. Backfilling of soils	32 months
Demolition, salvaging and site renovation	6 months
Total Time	56 months

Permitting Requirements

This alternative involves the removal and treatment of battery casings, soils, sediments, and matte. Battery casing products (lead, ebonite, plastic, etc.) will be sent to reprocessing facilities and treated soils, sediments, and matte will be backfilled on site. The owner will have to ensure that the recipient of the battery casings meets RCRA TSD requirements for processing hazardous waste as is in compliance with the EPA Off-Site Policy. In construction, process facilities will be built, site drainage systems emplaced, air monitors installed, and after treatment, the facilities demolished. Construction permits will be required for these activities.

Community Concerns

Alternative 10 would address the community concern about high levels of airborne lead as well as the effects of airborne lead on workers' health. This alternative would be likely to encounter the least community opposition because of the final condition of the site. However, strong opposition to the short-term effects of remediation can be anticipated. Affected populations (nearby workers and in nearby residences) can be expected to oppose any action at the site that will increase airborne lead, as any site remediation will unavoidable do. Such opposition will be stronger for Alternative 10 than for any of the alternatives discussed thus far, because of the more rigorous approach to site treatment. This alternative is rated as high in satisfying community concerns.

Institutional Controls

For Alternative 10, the site is left in a completely remediated condition. Battery casings and other source materials would be gone from the site, contaminated soils would be stabilized, East Doane Lake would be treated, and groundwater would be treated.

The only restrictions would relate to disturbance of remediated soils, since unlimited activity could gradually break down the stabilized matrix. The land use restriction mechanism of the Oregon Notice of Environmental Hazards Act could be used to restrict future site development or activity to avoid any undesired activity.

As with all other alternatives, Gould Inc. has the right to place notices on the deed or other instrument restricting use of the property. This control could be used instead of, or in combination with, the land

use restriction mechanism to avoid undesired site activity. There would be no need for further site institutional control. The ability of the alternative to meet institutional requirements and its ease of implementation from an institutional control stance is high.

Availability

At the present time, equipment that can separate the mixed battery casing materials on site into recyclable components is unavailable. The reader is referred to the Section 5 discussion on engineering studies that have been performed to determine the applicability of separation equipment to the Gould site. Prior to the conduct of the RI/FS, Alchem Western brought recycling equipment to the site; it failed. During the RI/FS, NL Industries, Inc. and Gould Inc. have conducted engineering studies on equipment manufactured by MA Industries and on equipment manufactured by Poly-Cycle Industries; both studies showed that the separated plastic and ebonite fail the test of TCLP for lead. Plastic does not fail badly, while ebonite samples show very high levels of total and leachable lead.

EPA has interpreted RCRA regulations regarding recycle of plastic, metallic lead, and ebonite from the site in a recent letter (see Appendix F). While EPA would allow recycle of plastic, metallic lead and ebonite without designation as hazardous waste, lead oxide would be required to be transported and treated as a hazardous waste. As such, any facility which may be interested in accepting the lead oxide for purposes of recovering the lead would have to be permitted as a TSD facility under 40 CFR Part 264. This requirement significantly reduces the availability of recycling options for lead oxide.

As an overall rating, the availability of equipment to effectively implement Alternative 10 is judged to be low.

6.6.3 Cost Analysis

The costs associated with this alternative are divided into two categories. The first is capital cost which includes site grading, parking drainage modification, lakeshore erosion control, excavation of materials for the processing plant, installation of airborne monitors, excavation of materials for the processing plant, replacement of fixated soils, revegetation and construction of a processing plant. The second is the operating cost which includes plant, heavy equipment rental, plant additives, plant labor, plant maintenance, plant demolition, and site monitoring. Operating costs are discounted to present worth for

comparison purposes. Detailed cost breakdown information is provided in Appendix C.

The costs for this type of study estimate are normally expected to be within about 30 percent of actual costs. However, for this alternative we have included a contingency of 50 percent to reflect the greater uncertainty associated with the alternative. Even with that contingency, the costs are only conceptual at this point, and as discussed below, could be low by a factor of 2 or 3 depending on the final configuration of the alternative. Clearly, the uncertainties are too great to allow meaningful comparisons of costs at this time.

	<u>Capital Costs</u>	<u>O&M Present Worth</u>	<u>Total Cost</u>
Alternative #10	\$4,810,692	\$4,427,840	\$9,238,532

Assumptions include:

- ° Site grading - 2.3 acres
- ° Pumping time - 550 hours
- ° Plant building - 18,000 sq. ft.
- ° Material processed - 108,450 cu. yd.
- ° Plant labor force - 12 people for 2 years
- ° Costing Interest Rate - 12 percent

The costs presented for Alternative 10 do not include any expense items for processes that may be necessary to remove interstitial lead from the ebonite, because at this time the ultimate efficiency of the ebonite separation equipment, which may render post-separation lead removal unnecessary, is unknown. Estimated costs for such removal processes were developed by the Bureau of Mines for a plant at the United Scrap Lead site near Troy, Ohio. The cost estimate is found in the Bureau of Mines report in Appendix B, under the section entitled "Economics".

The Bureau estimates the cost for a lead-from-ebonite plant with a capacity of 30 tons per hour, about 50 percent larger than the plant discussed above for the Gould site. The key differences between the United Scrap Lead process and the Gould site process is that the United Scrap Lead plant would be designed to remove interstitial lead from ebonite, through the use of a number of leaching steps. Given this difference, the Bureau of Mines estimated a total operating cost of \$11.3 million. A credit of \$3.0 million for recycled materials leaves a net operating cost of \$8.3 million for the plant.

The \$11.3 million cost for the ebonite plant may be an additive cost for the Gould site, since the Bureau of Mines estimate assumes separated ebonite for a feedstock, rather than mixed casing material. As such, the ultimate cost for the Gould site may be as high as \$20 million or more, if the present Alternative 10 estimate of \$9.2 million is added to the Bureau of Mines estimate.

6.7 ALTERNATIVE 21 EVALUATION

Alternative 21 consists of excavation of battery casings and matte, permanent disposal of battery casings in an on-site RCRA landfill or tumulus, regrading the site to drain away from East Doane Lake, stabilization of contaminated surface soils, subsurface soils, sediments, and matte, blocking the East Doane Lake outlet to the Willamette, filtration of East Doane Lake, and monitoring.

Alternative 21 mitigates the problem by removing the surface soils, sub-surface soils, sediments and matte and treating them with a fixation agent to bind the contaminants in a soil matrix. The battery casings are also removed and then disposed of in an on-site tumulus.

6.7.1 Effectiveness

Endangerment Assessment

Alternative 21 achieves 99.8 percent of the overall reduction in exposure to lead achievable by Alternative 10 for the base case. For the high dose case, reductions are the same for the two alternatives.

Short-term risks for workers onsite would be negligible because workers onsite would follow health and safety procedures and use personal protective equipment where warranted. In addition, fencing and other controls would be used to prevent members of the public from entering the site. The hazard index for inhalation of lead by offsite workers at the fenceline is well within the acceptable chronic intake.

Reliability

The removal of and treatment of contaminated material in the methods prescribed by this alternative will remove recharge contaminant sources for groundwater and prevent airborne migration of contaminants. The disposal of battery casings in an on-site RCRA tumulus is a reliable and acceptable method of disposing of hazardous waste. Reliability of tumulus is lessened by possibility of leachate generation and by inspection requirements.

Fixation of heavy metals in soil has been performed at other sites with a certain degree of reliability, although more study is needed to determine the agent most suitable and dosing requirement to meet leachability testing. The agent binds the heavy metals in a matrix with soil making them non-mobile. Future mobility could only be induced by a chemical or physical means such as oxidation with an acid or mechanical disturbance. The placement of a soil and vegetative cover over the backfill will further prevent oxidation by weathering. The reliability of this alternative is considered moderate.

Conformance with ARARs

Many of the same site considerations for achievement of ARARs that apply to Alternative 10 would apply to Alternative 21 as well. All source materials are being remediated. Short-term impacts will likely be similar for Alternative 21 as for Alternative 10.

Removal of contaminated sediments containing leachable lead, combined with filtration of the lake, will reduce the amount of time necessary to reduce the lead content of the lake water of East Doane lake. Through time, the pH of East Doane Lake can be expected to rise, as the sulfate plume on the site is further diluted. A gradual rise in lake pH will gradually reduce the dissolved component of lead in the lake. Filtration of the lake will more quickly reduce the non-dissolved portion of lake lead than continued settling. Reduction of both dissolved and non-dissolved lake lead will, in all likelihood, be adequate to allow East Doane Lake to achieve the ARAR for lead of 0.05 mg/l. With the outlet to the Willamette closed, the Willamette will be protected from any contaminant plume from East Doane Lake discharge.

Since the National Ambient Air Quality Standard (NAAQS) for lead of 1.5 ug/m3 for a calendar quarter would not be exceeded for the No-Action Alternative during periods of no or low site activity, it would not be exceeded long-term for Alternative 21 either. During actual site remediation under Alternative 21, total suspended particulates would show a significant rise, as would the concentration of airborne lead. The percentage of lead in airborne particulates would be significantly reduced over the long-term.

The MCL for lead would continue to be exceeded in some of the monitoring wells, at least at the outset. Through time, the ground-water pH of all on-site wells can be expected to rise as the sulfate plume on the site is further diluted. A gradual rise in ground-water pH will gradually reduce the dissolved component of lead in the shallow aquifer

system. Over time, this reduction couple with removal of all primary source materials and stabilization of all secondary source materials should be adequate to allow groundwater in on-site wells to achieve the ARAR for lead of 0.05 mg/l. Actual time required to achieve the ARAR will depend on the amount of precipitation received, since runoff will be diverted away from the site and made unavailable as a source of recharge. At present, there is no consumptive use of the aquifer, and publicity combined with institutional controls may continue to prevent consumptive use until the aquifer achieves the ARAR.

Alternative 21 directly treats the materials on site that are primary or secondary sources of lead, i.e. battery casings, matte, surface soils, subsurface soils, and sediments. No materials that fail the standard of EP Toxicity for lead will remain uncontrolled at the end of remediation under Alternative 21. The ability of remedial action to meet ARARS under Alternative 21 is judged to be high.

Reduction in Toxicity, Mobility, or Volume

As stated previously, the fixation process for soils will reduce toxicity and mobility of the contaminants, it will, however, not reduce the volume. The volume of the treated soil material will actually increase about 0.5 percent due to the additive and 5 percent because compaction by normal methods will achieve a 95 percent of the in-situ conditions. Disposing of the battery in a tumulus does not reduce toxicity or volume. Because the tumulus does isolate the waste from the surrounding environment, it does effectively prevent mobility. Compaction in the tumulus will be limited to 85 to 95 percent, thereby increasing the waste volume. The reduction of toxicity, mobility, or volume, in this alternative, is considered moderate to high.

6.7.2 Implementability

Constructability

The sitework and construction of facilities in this alternative will be performed using standard methods and equipment. The site is in an industrial area with good utility access; however, disruption of local services or utilities is foreseen during the construction period. For Alternative 21, which involves excavation at the site, the location of power lines along the northwest edge of the Gould property must also be considered. The Bonneville Power Administration (BPA) maintains a 115-kV transmission line on the Rhone-Poulenc and ESCO properties that feeds one of the BPA's Direct Service Industries. The BPA indicates

that this line serves a heavy user of power that typically shuts down for only a few days each year for maintenance. Thus, removal or relocation of the transmission line may entail a loss of revenue for the power user, as well as additional costs associated with on-site work and new construction. On the other hand, the operation of heavy equipment near an energized transmission line may constitute a significant safety hazard. In addition, Portland Power and Light maintains a power line alongside the transmission line, at roughly half the elevation of the BPA line. As noted in "time required", the battery casings must be excavated and stored on a temporary pad until the soils have been processed, before the tumulus can be constructed. The constructibility factor of this alternative is considered moderate.

Performance

The treatment plants, once set-up, would be manned by locally trained operators with supervision by a small technical staff. Process performance would be controlled according to strict procedures and a quality control program. Backfilling of the treated soils will be done according to standard construction procedures. Therefore no specialist requirements are foreseen to achieve performance goals. The soil, when fixed and the soilvegetative protective cover is in place, should remain in the immobile condition indefinitely. The disposal of battery casings in a RCRA tumulus is a regulatory acceptable method of isolating waste. However, the waste is still toxic and remains on site. Considering that the leak detection and leachate collection system of this tumulus is inspected daily for 30 years, the long term performance is assured. The performance factor for this alternative is considered moderate to high.

Safety

The process for soils uses no chemicals that are harmful by normal contact to the operators. The soils materials could be harmful if inhaled or ingested. Personnel in these areas will wear protective clothing and gloves. In the dry handling areas, the operators will be required to wear safety masks. On-site contractors handling waste materials will be required to have personnel who are health and safety trained. Technical staff will implement safety programs in the process plant. In the training program for local operators, a segment will be devoted to health and safety. A safety inspector will make periodic checks of conditions and programs ensuring adherence. The safety factor for this alternative is considered to be moderate.

Time Required

The time required to perform this alternative is extended because the tumulus extends over the area where the process facility, soils, and battery casings are located, therefore processing the materials must be completed before construction of the tumulus can begin. The time required to perform this alternative is outlined in the following sequential activities:

- ° Remedial design, specification, procurement, contracting, and permitting 12 months
- ° Construction of a temporary storage pad for battery casings 2 months
- ° Excavation of soils, sediments, and matte. Excavation of battery casings and placement on temporary storage pad. 6 months
- ° Facility Construction 5 months
- ° Processing of soil materials and back-filling on-site 24 months

Permitting Requirements

This alternative involves the removal and treatment of soils, sediments and matte to fix the contaminants and then backfill the materials on site. The battery casings will be disposed of in an onsite landfill. The landfill will have to meet the requirements of RCRA and be constructed to 40 CFR Part 264 Standards. In construction, process facilities will be built along with the landfill. Construction permits will be required for these activities.

Community Concerns

Alternative 21 would address the community concern about high levels of airborne lead as well as the effects of airborne lead on workers' health. This alternative would also alleviate concerns about future development of the Doane Lake area because it would result in fewer restrictions on future land uses than would the No-Action Alternative. However, strong opposition to the short-term effects of remediation can be anticipated. Affected populations (nearby workers and in nearby residences) can be expected to oppose any action at the site that will increase airborne lead, as any site remediation will unavoidable do.

The appearance of the RCRA tumulus is also likely to encounter some opposition. A large, high, perpetual mound of battery casings in the middle of the property is not likely to be well-received by those whose location would permit daily viewing of such a structure. The community acceptance of Alternative 21 is judged to be moderate.

Institutional Controls

For Alternative 21, the site is left in a completely remediated condition. Battery casings and other source materials would be entombed in a RCRA tumulus, contaminated soils would be stabilized, East Doane Lake would be isolated from the Willamette, and ground water would be treated. The institutional requirements of the alternative are moderate; all site contaminants are addressed, however the lead time to obtain a RCRA permit for the landfill (tumulus) will likely be quite long.

Certain site restrictions would be required as specified under 40 CFR 264 Subpart G. These restrictions relate to post-closure care and notifications for a RCRA facility closed with waste in place. The restrictions include requirements for benchmarks to mark the location of the waste, land use restrictions prohibiting the disturbance of the tumulus cap, restrictions on public access to the property, and notices to be placed on deeds or on other instruments normally examined during a title search. Such restrictions, including restricted access, would adequately prevent human health exposure or environmental exposure to site contaminants. The institutional requirements for Alternative 21 are judged to be moderate.

Availability

The equipment and materials needed to implement Alternative 21 are readily available. Additional testing will be required to choose the proper method for source material stabilization. The availability of Alternative 21 is judged to be high.

6.7.3 Cost Analysis

The costs associated with this alternative are divided into two categories. The first is capital cost which includes site grading, parking drainage modification, installation of airborne monitors, lakeshore erosion control, revegetation, fixation plant construction, temporary storage pad construction, RCRA permitting, installation of monitoring wells, and construction of the on-site storage vault. The second is the operating cost which includes excavation and replacement

of materials, demolition of existing buildings, plant additives, plant labor, heavy equipment rental, plant demolition and site monitoring. Operating costs are discounted to present worth for comparison purposes. Detailed cost breakdown information is provided in Appendix C.

	<u>Capital Costs</u>	<u>O&M @ 12% Present Worth</u>	<u>Total Cost</u>
Alternative #21	\$6,108,616	\$4,083,408	\$10,192,024

Assumptions include:

- ° Site grading - 2.3 acres
- ° Plant building size - 900 sq. ft.
- ° Battery casings - 80,000 cu. yd.
- ° Plant labor force - 8 men for two years
- ° Costing interest rate - 12 percent

6.8 ALTERNATIVE 25 EVALUATION

Alternative 25 comprises removal and on-site disposal of contaminated site materials in a RCRA-approved tumulus. The alternative includes site regrading and blocking of the overflow from the East Doane Lake remnant, surface capping, and a long-term monitoring program.

6.8.1 Effectiveness

Endangerment Assessment

Alternative 25 achieves 99.8 percent of the overall reduction in exposure to lead achievable by Alternative 10 for the base case. For the high dose case, reductions are the same for the two alternatives.

Short-term risks for workers onsite would be negligible because workers onsite would follow health and safety procedures and use personal protective equipment where warranted. In addition, fencing and other controls would be used to prevent members of the public from entering the site. The hazard index for inhalation of lead by offsite workers at the fenceline is well below the acceptable chronic intake.

Reliability

The removal and on-site disposal of the site contaminants is considered a reliable means of eliminating pollution from the site. Frequent inspection of the cap will be required to ascertain that the cap maintains an impermeable barrier between the contaminants and the environment. Site monitoring equipment will require continued maintenance, as well. The reliability of this alternative is rated moderate.

Conformance with ARARs

Alternative 25 consists of excavation of battery casings and matte, permanent disposal of battery casings, matte, surface soils, subsurface soils, and sediments in an on-site RCRA landfill or tumulus, regrading the site to drain away from East Doane Lake, blocking the East Doane Lake outlet to the Willamette, filtration of East Doane Lake, and monitoring.

Many of the same site considerations for achievement of ARARs that apply to Alternatives 10 and 21 would apply to Alternative 25 as well. All source materials are being remediated. Short-term impacts will likely be similar for Alternative 25 as for Alternatives 10 and 21.

Removal of contaminated sediments containing leachable lead, combined with filtration of the lake, will reduce the amount of time necessary to reduce the lead content of the lake water of East Doane lake. Through time, the pH of East Doane Lake can be expected to rise, as the sulfate plume on the site is further diluted. A gradual rise in lake pH will gradually reduce the dissolved component of lead in the lake. Filtration of the lake will more quickly reduce the non-dissolved portion of lake lead than continued settling. Reduction of both dissolved and non-dissolved lake lead will, in all likelihood, be adequate to allow East Doane Lake to achieve the ARAR for lead of 0.05 mg/l. With the outlet to the Willamette closed, the Willamette will be protected from any contaminant plume from East Doane Lake discharge.

Since the National Ambient Air Quality Standard (NAAQS) for lead of 1.5 ug/m3 for a calendar quarter would not be exceeded for the No-Action Alternative during periods of no or low site activity, it would not be exceeded long-term for Alternative 25 either. During actual site remediation under Alternative 25, total suspended particulates would show a significant rise, as would the concentration of airborne lead. The percentage of lead in airborne particulates would be significantly reduced over the long-term.

The MCL for lead would continue to be exceeded in some of the monitoring wells, at least at the outset. Through time, the ground-water pH of all on-site wells can be expected to rise as the sulfate plume on the site is further diluted. A gradual rise in ground-water pH will gradually reduce the dissolved component of lead in the shallow aquifer system. Over time, this reduction couple with removal of all primary source materials and stabilization of all secondary source materials should be adequate to allow groundwater in on-site wells to achieve the

ARAR for lead of 0.05 mg/l. Actual time required to achieve the ARAR will depend on the amount of precipitation received, since runoff will be diverted away from the site and made unavailable as a source of recharge. At present, there is no consumptive use of the aquifer, and publicity combined with institutional controls may continue to prevent consumptive use until the aquifer achieves the ARAR.

Alternative 25 directly treats the materials on site that are primary or secondary sources of lead, i.e. battery casings, matte, surface soils, subsurface soils, and sediments. No materials that fail the standard of EP Toxicity for lead will remain uncontrolled at the end of remediation under Alternative 25. However, because there is no preference for treatment or permanence under SARA, the performance of Alternative 25 in meeting ARARs is moderate.

Reduction in Toxicity, Mobility, or Volume

Alternative 25 does not significantly reduce the volume or toxicity of the site contaminants. Contaminant mobility is significantly reduced by lessening the availability of site contaminants for wind entrainment or dissolution in surface water. This alternative is rated moderate for reducing contaminant toxicity, mobility or volume.

6.8.2 Implementability

Constructability

Alternative 25 would be accomplished using conventional machinery and techniques. During construction of the tumulus, though, excavated wastes would have to be placed on an adjacent property. Temporary storage of excavated material must comply with 40 CFR 265.253 and 265.254. Off-site storage might also require special arrangements with state and local agencies and authorities, and special agreements with neighboring property holders. For Alternative 25, which involves excavation at the site, the location of power lines along the northwest edge of the Gould property must also be considered. The Bonneville Power Administration (BPA) maintains a 115-kV transmission line on the Rhone-Poulenc and ESCO properties that feeds one of the BPA's Direct Service Industries. The BPA indicates that this line serves a heavy user of power that typically shuts down for only a few days each year for maintenance. Thus, removal or relocation of the transmission line may entail a loss of revenue for the power user, as well as additional costs associated with on-site work and new construction. On the other hand, the operation of heavy equipment near an energized transmission

line may constitute a significant safety hazard. In addition, Portland Power and Light maintains a power line alongside the transmission line, at roughly half the elevation of the BPA line. This alternative is therefore rated moderate for constructability.

Performance

The intent of this alternative is to fully mitigate potential health and environmental effects of site contaminants by completely isolating the contaminants from the environment. Site regrading and blocking of the overflow from the East Doane Lake remnant will prevent the accumulation of runoff in the lake remnant, and eliminate any possibility of movement of contaminated surface water off site. Tumulus cap and leachate systems will require regular monitoring and inspection, however. When combined with appropriate institutional controls, the performance of this alternative is judged to be moderate to high.

Safety

During remediation, worker safety issues similar to those for major earthmoving projects will exist. Hazards associated with site contaminants will be reduced by appropriate respiratory protection, worker safety attire and the application of dust suppression techniques.

The monitoring program for Alternative 25 will be similar to that discussed under Alternative 21 in Section 6.2.6. The monitoring program will use monitoring wells to look for changes in the groundwater contaminant plume. Implementation of the monitoring program will not involve any significant safety issues. Overall, this alternative is rated moderate for safety.

Time Required

As with Alternative 21, Alternative 25 could be executed in approximately four years, including planning, review, contracting and completion. There are no site conditions or known zoning requirements which might delay execution; but the application for and approval of RCRA permits for the tumulus and the temporary waste storage pile could delay execution. Beneficial effects of remediation under this alternative will be immediate upon completion of construction.

Permitting Requirements

This alternative involves the removal of battery casings, soils, sediments, and matte, which will all be disposed of in a RCRA onsite landfill. The landfill will have to meet the requirements of RCRA and be constructed to 40 CFR Part 264 Standards. In construction, monitoring systems will be installed, site drainage systems emplaced, and buildings demolished. Construction permits will be required for these activities.

Community Concerns

Alternative 25, like Alternative 21, would address the community concern about high levels of airborne lead as well as the effects of airborne lead on workers' health. This alternative would also alleviate concerns about future development of the Doane Lake area because it would result in fewer restrictions on future land uses than would the No-Action Alternative. However, strong opposition to the short-term effects of remediation can be anticipated. Affected populations (nearby workers and in nearby residences) can be expected to oppose any action at the site that will increase airborne lead, as any site remediation will unavoidable do.

Even more than for Alternative 21, the appearance of the RCRA tumulus under this alternative is likely to encounter opposition. A very large, very high, perpetual mound of battery casings and soil in the middle of the property is not likely to be well-received by those whose location would permit daily viewing of such a structure. The community acceptance of this alternative is likely to be moderate.

Institutional Controls

For Alternative 25, the site is left in a completely remediated condition. Battery casings and other source materials, along with secondary source materials and sediments would be entombed in a RCRA tumulus, East Doane Lake would be isolated from the Willamette, and ground water would be treated. The institutional requirements of the alternative are moderate; all site contaminants are addressed, however the lead time to obtain a RCRA permit for the landfill (tumulus) will likely be quite long.

Certain site restrictions would be required as specified under 40 CFR 264 Subpart G. These restrictions relate to post-closure care and notifications for a RCRA facility closed with waste in place. The

restrictions include requirements for benchmarks to mark the location of the waste, land use restrictions prohibiting the disturbance of the tumulus cap, restrictions on public access to the property, and notices to be placed on deeds or on other instruments normally examined during a title search. Such restrictions, including restricted access, would adequately prevent human health exposure or environmental exposure to site contaminants. The institutional requirements for Alternative 25 are judged to be moderate.

Availability

The equipment and materials needed to implement Alternative 25 are readily available. The availability of Alternative 25 is judged to be high.

6.8.3 Cost Analysis

The costs associated with this alternative are divided into two categories. The first is capital cost which includes excavation of clean soils, pumping of East Doane Lake, lakeshore erosion control, parking lot restructuring, installation of airborne monitors, importing backfill, installation of monitoring wells, RCRA permitting, construction of the temporary storage pad and on-site vault construction. The second is the operating cost which includes the excavation and transportation of materials to the temporary storage pad, placement of materials in the RCRA vault, water truck rental, and site monitoring. Operating costs are discounted to present worth for comparison purposes. Detailed cost breakdown information is provided in Appendix C.

	<u>Capital Costs</u>	<u>O&M @ 12% Present Worth</u>	<u>Total Cost</u>
Alternative #25	\$11,246,577	\$ 336,368	\$11,582,945

Assumptions include:

- ° Vault Capacity - 114,157 cu. yd.
- ° Imported Fill - 160,000 cu. yd.
- ° Costing Interest Rate - 12 percent

6.9 SUMMARY OF DETAILED EVALUATION OF ALTERNATIVES

The results of the detailed evaluation of alternatives presented in Section 6.2 through 6.8 are combined in Tables 6.9-1 through 6.9-3. The results of the non-cost evaluations in Table 6.9-1 are summarized for each alternative using the high-moderate-low rating system. The results

of the cost evaluation are summarized in total present worth dollars for a 30-year project life at a 12 percent discount rate. This summary of the detailed evaluation is utilized in Section 7.0 to perform the final ranking of alternatives.

TABLE 6.9-1 SUMMARY OF COST ESTIMATES

GOULD RI/FS
FEASIBILITY STUDY COST ESTIMATES

	Alt. 1	Alt. 2A	Alt. 2B	Alt. 8	Alt. 10	Alt. 21	Alt. 25
Direct							
Site Improvements	\$23,600	\$112,807	\$550,855	\$577,705	\$125,560	\$128,961	\$1,802,815
Soils Handling					827,016	81,779	81,779
Process Plant					1,893,988	660,080	
Storage Facilities						2,528,997	3,431,202
Materials Handling		352,235	280,733	1,397,401		442,080	1,757,523
subtotal	23,600	465,042	831,588	1,975,106	2,846,563	3,841,897	7,073,319
Indirect	11,092	218,570	407,478	967,802	1,964,129	2,266,719	4,173,258
Present worth (O&M)							
5.0%	\$295,300	\$774,867	\$268,345	\$345,976	\$4,877,572	\$4,814,659	\$588,803
10.0%	182,975	455,767	165,423	213,029	4,554,981	4,256,073	384,090
12.0%	156,962	382,092	138,952	181,793	4,427,840	4,083,408	336,368
15.0%	128,641	302,330	115,775	148,933	4,271,838	3,857,853	284,119
Present worth (O&M + Capital)							
5.0%	\$329,992	\$1,458,478	\$1,507,411	\$3,288,884	\$9,688,263	\$10,923,275	\$11,835,380
10.0%	217,667	1,139,378	1,404,489	3,155,937	9,365,673	10,364,689	11,630,667
12.0%	191,654	1,065,703	1,378,017	3,124,701	9,238,532	10,192,024	11,582,945
15.0%	163,333	985,941	1,354,841	3,091,841	9,082,530	9,966,469	11,530,695

TABLE 6.9-2 Summary of the Effectiveness Evaluation

Remedial Alternatives	CRITERIA				OVERALL EFFECTIVENESS RATING
	Effectiveness				
	Protectiveness				
	Public Health and Environmental Impacts	Reliability	Conformance to ARARs	Reduction in Toxicity, Mobility or Volume	
Alternative 1 -- No Action Monitoring Institutional Controls	Continued risks to on-site workers and potential residents from soil ingestion and airborne lead. Risk to aquatic species. RATING: LOW	Indefinite need to provide well and pump maintenance; generally reliable, proven technology RATING: HIGH	ARARs for lead in water, primary source materials, secondary source materials not attained. RATING: LOW	No reduction in toxicity, mobility, or volume. RATING: LOW	LOW
Alternative 2A Monitoring Surface Treatment with Lime Battery Casings Surface Piles Treatment/Disposal Institutional Controls	Little reduction in risk from potential soil ingestion. Some reduction in airborne lead. RATING: LOW	Regular repetition of surface treatment required; indefinite need to provide well and pump maintenance RATING: MODERATE	ARARs for lead in water, primary source materials, secondary source materials not attained. RATING: MODERATE	Reduction in mobility only RATING: LOW	LOW TO MODERATE
Alternative 2B Monitoring Surface Capping Battery Casings Surface Piles Treatment/Disposal Institutional Controls	Reduction in risk from soil ingestion and from airborne lead. Restricted access to site offers satisfactory protection. RATING: MODERATE	Regular inspection of soil/bentonite cap required. No other reliability considerations. RATING: MODERATE TO HIGH	Invocation of waiver under SARA would allow alternative to be implemented without meeting all ARARs. RATING: MODERATE TO HIGH	Reduction in mobility of contaminants and indirect reduction in toxicity. RATING: MODERATE TO HIGH	MODERATE TO HIGH
Alternative 8 Monitoring Surface Capping Battery Casings Surface Piles Treatment/Disposal Sediment Treatment/Disposal Institutional Controls	Reduction in risk from soil ingestion and from airborne lead. Restricted access to site offers more protection. RATING: MODERATE	Regular inspection of soil/bentonite cap required. No other reliability considerations. RATING: MODERATE TO HIGH	Invocation of waiver under SARA would allow alternative to be implemented without meeting all ARARs. RATING: MODERATE TO HIGH	Reduction in mobility of contaminants and indirect reduction in toxicity. Reduction in volume by removing sediments. RATING: MODERATE TO HIGH	MODERATE TO HIGH
Alternative 10 Monitoring Surface Capping Battery Casings Treatment/Disposal Soil, Sediment & Matte Treatment/Disposal	Short-term risks mitigated by use of Health & Safety equipment during remedial work. Long-term risks acceptable. RATING: MODERATE	High O&M requirements on battery separations and soils treatment processes; battery separations process unproven. RATING: MODERATE TO HIGH	ARARs are more nearly met than for any other alternative. Preference for treatment and permanence of remediation under SARA is met. RATING: MODERATE TO HIGH	Recycling of a majority of the site hazardous materials; reduction in toxicity or mobility of remaining contaminants. RATING: MODERATE TO HIGH	MODERATE TO HIGH

TABLE 6.9-2 Summary of the Effectiveness Evaluation

Remedial Alternatives	CRITERIA				OVERALL EFFECTIVENESS RATING
	Effectiveness				
	Protectiveness				
	Public Health and Environmental Impacts	Reliability	Conformance to ARARs	Reduction in Toxicity, Mobility or Volume	
Alternative 21 Monitoring Surface Capping Battery Casings On-Site Disposal Soil, Sediment & Matte Treatment/Disposal Institutional Controls	Short-term risks mitigated by use of Health & Safety equipment during remedial work. Long-term risks acceptable.	Indefinite on-site landfill maintenance and inspection requirements; high O&M requirements on soils treatment process; landfill construction is proven technology.	ARARs are nearly met. Preference for treatment and permanence of remediation under SARA is not emphasized.	Substantial reduction in toxicity or mobility of site contaminants: achieved by treatment and by making contaminants unavailable through on-site disposal.	MODERATE TO HIGH
	RATING: HIGH	RATING: MODERATE	RATING: HIGH	RATING: MODERATE TO HIGH	
Alternative 25 Monitoring Surface Capping Battery Casings On-Site Disposal Soil, Sediment & Matte On-Site Disposal Institutional Controls	Short-term risks mitigated by use of Health & Safety equipment during remedial work. Long-term risks acceptable.	Indefinite on-site landfill maintenance and inspection requirements; landfill construction is proven technology.	ARARs are nearly met. There is no preference for treatment or permanence of remediation under SARA.	Substantial reduction only in the mobility of site contaminants: achieved by making contaminants unavailable through on-site disposal.	MODERATE TO HIGH
	RATING: HIGH	RATING: MODERATE	RATING: MODERATE TO HIGH	RATING: MODERATE	

7.0 SUMMARY AND COMPARISON OF THE ALTERNATIVES

This section summarizes the detailed evaluation of the final candidate remedial action alternatives which was presented in Section 6.0. The detailed evaluation in Section 6.0 discussed the cost-effectiveness of each of the final remedial alternatives in terms of their technical, institutional, and public health and environmental attributes. In this section, the advantages and disadvantages of each of the alternatives relative to these attributes are reviewed. In addition, an alternative is recommended for implementation.

7.1 SUMMARY OF THE FINAL CANDIDATE ALTERNATIVES

Key technical, institutional, and public health and environmental features of the final candidate alternatives are listed in Table 7.1-1. In the following section, the advantages and disadvantages of the alternatives are discussed. For alternatives with similar attributes, distinct and significant differences are highlighted.

7.1.1 Alternative 1, No-Action Alternative

Of the final candidate alternatives, the No-Action Alternative has the lowest present-worth cost (\$191,654, assuming an interest rate of 12 percent). This alternative does not appear to threaten existing drinking water supplies. There do not appear to be any unacceptable health risks to current populations in the area, although the risk assessment indicates that an on-site worker may be exposed to site contaminants in excess of background levels. The No-Action Alternative relies on institutional controls and monitoring for the protection of public health and the environment.

Disadvantages of the No-Action Alternative include:

- ° Substantial amounts of wastes would be left in place on site. These wastes could continue to pose inhalation and ingestion problems in the future.
- ° Continued migration of site contaminants into the ground-water aquifers, although the plume of contaminated ground water will likely continue to contract with time as the pH of the ground water continues to rise.
- ° Failure to meet ARARs.

TABLE 7.1-1

SUMMARY OF THE DETAILED EVALUATION OF THE FINAL CANDIDATE ALTERNATIVES

Remedial Alternatives	Effectiveness Rating	Implementability Rating	PW Cost Estimate (at 12% interest)
Alternative 1 -- No Action	Low	Low	\$ 191,654
Alternative 2A Surface Treatment w/ Lime Battery Casings Off-Site Disposal (Surface Piles) Institutional Controls	Low to Moderate	Moderate	\$1,065,703
Alternative 2B Surface Capping Battery Casings Off-Site Disposal (Surface Piles) Institutional Controls	Moderate to High	Moderate to High	\$1,378,017
Alternative 8 Surface Capping Battery Casings Off-Site Disposal (Surface Piles) Sediment Off-Site Disposal Institutional Controls	Moderate to High	Moderate to High	\$3,124,701
Alternative 10 Surface Capping Battery Casings Removal for Treatment/Disposal/Recycle Soil, Sediment & Matte On-Site Treatment Institutional Controls	Moderate to High	Low	\$9,238,532
Alternative 21 Surface Capping Battery Casings On-Site Disposal Soil, Sediment & Matte On-Site Treatment Institutional Controls	Moderate to High	Moderate	\$10,192,024
Alternative 25 On-Site Disposal Institutional Controls	Moderate to High	Moderate to High	\$11,582,945

- Unacceptable average daily doses under the on-site residential and off-site residential scenarios, and exposures considerably above background under the on-site worker scenario.
- Requirements for institutional restriction of site access, land use and new well water use.

7.1.2 Alternative 2A

At a present worth cost of \$1,065,703, Alternative 2A is the least expensive remedy after the No-Action Alternative. Advantages of this alternative include:

- Low cost.
- Ease of implementation and availability of necessary equipment and manpower.
- The potential for completing remediation in a relatively short period of time.
- Acceptability of short-term hazards associated with remediation, as indicated by hazard indices for the inhalation of lead.
- Reduction of contaminant migration in surface water.
- Gradual reduction of contaminant solubility in the East Doane Lake remnant.
- Gradual reduction of contaminant migration in ground water. Vertical infiltration of surface water will tend to raise the pH of the ground-water aquifers below the site, thereby reducing lead solubility.

Disadvantages of this alternative include:

- Substantial amounts of source materials left in place on site.
- Continued migration of site contaminants into the ground-water aquifers, although the plume of contaminated ground water will likely continue to contract with time as the pH of the ground water continues to rise.
- Long-term exposure risks for on-site workers and onsite residences which exceed AICs.

- ° Failure to meet all ARARs.
- ° Requirements for institutional restriction of site access, land use and new well water use.

7.1.3 Alternative 2B

At a present worth cost of \$1,378,017, Alternative 2B is a relatively inexpensive remedy.

Advantages of this alternative include:

- ° Low cost.
- ° Ease of implementation and availability of necessary equipment and manpower.
- ° The potential for completing remediation in a relatively short period of time.
- ° When coupled with institutional controls, protection of public health and the environment is equivalent to meeting ARARs.
- ° Acceptability of short-term hazards associated with remediation, as indicated by hazard indices for the inhalation of lead.
- ° Reduction of contaminant migration in air and in surface water.

Disadvantages of this alternative include:

- ° Substantial amounts of source materials left in place on site.
- ° Continued horizontal migration of site contaminants in the ground-water aquifers, although the plume of contaminated ground water will continue to contract with time as the pH of the ground water continues to rise.
- ° Long-term exposure risks for ingestion which exceed the acceptable chronic intake by about 20 percent, but only for the on-site residential exposure scenario precluded under the alternative. (This risk is mitigated by several factors discussed in the Endangerment Assessment.)
- ° Requirements for institutional restriction of site access, land use and new well water use.

7.1.4 Alternative 8

At a present worth cost of \$3,124,701, Alternative 8 is substantially more expensive than Alternatives 2A or 2B, but is also substantially less expensive than Alternatives 10, 21 or 25.

Advantages of this alternative include:

- ° Ease of implementation and availability of necessary equipment and manpower.
- ° The potential for completing remediation in a relatively short period of time.
- ° When coupled with institutional controls, protection of public health and the environment is equivalent to meeting ARARs.
- ° Acceptability of the short-term hazards associated with remediation, as indicated by hazard indices for the inhalation of lead.
- ° Reduction of contaminant migration in air and in surface water.

Disadvantages of this alternative include:

- ° Substantial amounts of source materials left in place on site.
- ° Continued migration of site contaminants into the ground-water aquifers, although the plume of contaminated ground water will likely continue to contract with time as the pH of the ground water continues to rise.
- ° Long-term exposure risks for ingestion which exceed the acceptable chronic intake by about 20 percent, but only for the on-site residential exposure scenario precluded under the alternative. (This risk is mitigated by several factors discussed in the Endangerment Assessment.)
- ° Failure to meet all ARARs.
- ° Requirements for institutional restriction of site access, land use and new well water use.

7.1.5 Alternative 10

At a present worth cost of \$9,238,532, Alternative 10 is substantially more expensive than Alternatives 2A, 2B or 8, but is also less expensive than Alternatives 21 or 25.

Advantages of this alternative include:

- ° Satisfaction of the SARA preference for alternatives which utilize permanent solutions and alternative treatment or resource recovery technologies.
- ° Removal and treatment of the majority of the contaminant source materials.
- ° Meets or exceeds ARARs.
- ° Limited requirements for institutional restriction of site access or land use.

Disadvantages of this alternative include:

- ° Additional bench- and pilot-scale tests required to ascertain the suitability and reliability of treatment processes for both soil and battery casing materials.
- ° Equipment and technology necessary for implementation is unavailable.
- ° Prolonged time for remediation.
- ° Failure of separations processes to provide a recyclable product which passes TCLP or EP Toxicity, and liabilities which may result from the recycling of hazardous material.
- ° Very high cost.

As evaluated in Section 6, Alternative 10 is not available for implementation. It is the intent of the PRPs to continue pursuing the technical feasibility of Alternative 10 through the conduct of additional engineering studies and other research.

7.1.6 Alternative 21

At a present worth cost of \$10,192,024, Alternative 21 is an expensive remedial alternative, given the risks imposed by the site.

Advantages of this alternative include:

- ° Availability of necessary equipment and manpower.
- ° Utilizes proven technologies.
- ° Provides permanent isolation or removal and treatment of the majority of the contaminant source materials.
- ° Meets or exceeds ARARs.

Disadvantages of this alternative include:

- ° Does not provide a permanent solution to all aspects of the site hazards.
- ° Additional bench- and pilot-scale tests required to ascertain the suitability and reliability of the soils treatment process.
- ° The relatively prolonged time required for remediation: since soils treatment must be completed before construction of the tumulus can begin, the time needed to complete remediation is greater than for most of the other alternatives.
- ° The necessity for storing hazardous materials from the site on an adjacent property.
- ° Requirements for institutional restriction of site access and land use.
- ° Demands long-term site monitoring.
- ° Very high cost.

7.1.7 Alternative 25

At a present worth cost of \$11,582,945, Alternative 25 is the most expensive of the final candidate alternatives.

Advantages of this alternative include:

- ° Availability of necessary equipment and manpower.
- ° Utilizes proven technologies.
- ° Provides permanent isolation for the majority of the contaminant source materials.
- ° Meets or exceeds ARARs.

Disadvantages of this alternative include:

- ° Remedy does not provide a permanent solution, and does not utilize alternative treatment technologies or resource recovery technologies.
- ° The necessity for storing hazardous materials from the site on an adjacent property.
- ° Requirements for institutional restriction of site access and land use.
- ° Demands long-term site monitoring.
- ° Very high cost.

7.2 RECOMMENDED REMEDIAL ALTERNATIVE

In light of the remedial objectives outlined in Section 3 of this report, and in light of the detailed evaluation provided for each of the Final Candidate Alternatives in Section 4, NL Industries and Gould Inc. recommend Alternative 2B to EPA and DEQ for remediation of the Gould site.

Alternative 2B comprises removal and off-site disposal of the surface piles of battery casing fragments, site regrading and blocking of the overflow from the East Doane Lake remnant, surface capping, institutional controls, and a long-term monitoring program. The recommendation is made with the knowledge that the alternative does not meet all ARARs for the Gould site. NL Industries and Gould Inc. have shown, however, that the remediation objectives can be met through the implementation of Alternative 2B.

The removal of surface piles of battery casings removes the major source of material available for airborne lead contamination, which was the reason the site was originally placed on the NPL. In addition,

removal of the surface piles accomplishes one of the primary objections that has been raised about the Gould site: the visual appearance of the casings. Surface capping of contaminated primary and secondary source materials removes the remainder of the sources of airborne lead contamination. In addition, application of a surface cap satisfactorily mitigates any concern that can reasonably be formulated about human or environmental exposure to ingestion of lead-contaminated material on the site.

Site regrading and blockage of the East Doane Lake outfall to the Willamette River removes the only significant source of lead contribution to the surface water of the Willamette. Satisfactory protection of aquatic species results.

Of key importance in the recommendation of Alternative 2B is the very aggressive and effective use of institutional controls in the alternative. The Feasibility Study has provided the basis for acceptability of institutional controls as an element of remediation. The EPA memorandum on institutional controls, reviewed independently by the Office of Policy Analysis, sets forth the structure for institutional controls at a CERCLA site, and concludes that such controls can be effective and integral elements of CERCLA site remediation. Adequate precedent exists for use of such controls, notably in the Western Processing Record of Decision within Region 10 (EPA 1985), and at the Pepper's Steel Record of Decision within Region 4 (EPA 1986).

As part of Alternative 2B, Gould Inc. will make use of institutional controls regarding future land ownership and use. Gould will covenant to maintain ownership and exercise limited use of the property in perpetuity, through the execution of an instrument, legally binding on Gould Inc., as well as on its heirs and successors. Gould Inc. will include a provision in the instrument regarding the possible future sale of the property. At such future time that Gould may, for circumstances unforeseen, be in a position that favors or requires the sale of the property, Gould or its heirs or successors will then re-evaluate the need for additional site remediation to protect human health and the environment.

The final element of the alternative is monitoring, which will be used to verify that site contaminants remain unavailable for exposure to people or the environment.

Given the commitment to be made by Gould Inc., there is an applicable waiver from meeting ARARS for a remedial action under Section 121

of SARA. That waiver is authorized when the proposed remedial alternative will attain the equivalent of the ARARs. The Endangerment Assessment has shown that for all exposure scenarios that do not include on-site residences (which are precluded under this alternative), Alternative 2B is adequately protective of human health and the environment. The alternative offers as much protection of the shallow ground-water aquifer off the site boundary as does any conceivable remedial measure, and the alternative satisfactorily mitigates the risks from contact with site contaminants. Those are the conditions to be met for EPA to apply the waiver.

The alternative is technically feasible, and it can be implemented within one year with readily available equipment, materials and labor. The alternative removes the contribution East Doane Lake makes to the Willamette, although minimal, thus alleviating any concern about aquatic species in the Willamette.

Finally, Alternative 2B is cost-effective. Given the lack of reliable information about the willingness of recyclers to accept separated source materials, and given the very high total lead levels found in the potentially recyclable materials, an excavate/treat/recycle alternative cannot be endorsed at this time. The cost of failure and the environmental effects of failure under such an option places the PRPs in an untenable position. Further, given the aggressive institutional controls proposed under Alternative 2B, there appears to be no practicable advantage to either constructing an on-site RCRA disposal facility or in providing stabilization of soils. As such, the cost cannot be justified.

Wacker Siltronic Corporation

WACKER

June 1, 1989

Mr. Fred Hansen, Director
Oregon Department of Environmental Quality
811 S.W. Sixth Avenue
Portland, Oregon 97204

Wacker Siltronic Corporation
P.O. Box 83180
Portland, OR 97283-0180
7200 N.W. Front Ave.
Portland, OR 97210-3676
Phone (503) 243-2020
FAX 503-226-0052
TWX 910-464-4777
TLX 4970339

Re: NL/Gould Site - Doane Lake Study Area

Dear Mr. Hansen:

I am writing in reply to your letter of April 27, 1989, to James H. DiSorbo, our president, and your letter of May 23, 1989, to me (and to representatives of other owners/operators in the Doane Lake area).

In your April 27 letter to Mr. DiSorbo you acknowledged receipt of his letter of March 24 and its accompanying legal memorandum to the Oregon Department of Justice for response to us. In your May 23 letter you invite the various addressees to meet with your staff during the next two weeks to negotiate a consent order by August 1, 1989.

As you know, the analysis by our legal counsel which you sent to the Oregon Department of Justice concludes that Wacker Siltronic is not liable under Oregon law for any remedial action costs. You have advised us, moreover, that among legally liable parties, it is DEQ policy to seek cleanup from "culpable" parties first, and only if this fails to achieve the necessary cleanup, to pursue property owners solely on the basis of ownership. Wacker Siltronic is neither legally liable, nor is it a "culpable" party.

Wacker Siltronic has not yet received a response from the Oregon Department of Justice. In view of this fact, it would not be useful for us to meet with your staff about a consent order. We do, however, look forward to a response from the Department of Justice and an opportunity to discuss that response with you as may be appropriate.

We remain, of course, ready to cooperate in providing access to our property as may be needed for your further study, subject to appropriate safeguards. If you have any questions, please call.

Sincerely yours,

WACKER SILTRONIC CORPORATION



John Pittman
Director of Engineering

cc: Jim DiSorbo
Marvin B. Durning

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